ERDC/CRREL TR-07-3

Cold Regions Research and Engineering Laboratory

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Blast Absorber Feasibility Test—Short Range Measurements

Aberdeen Test Center, MD
13–17 June 2005

Frank E. Perron Jr., Stephen N. Decato,
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March 2007

Cover: Detonation of a C4 explosive charge above a thick layer of gravel. (Photo by Joe Ulrich, ATC.)

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Prepared for U.S. Army Corps of Engineers

Abstract: Complaints about Army training noise, especially artillery noise, are increasing and are impacting soldier training opportunities. One suggested mitigation method is to use a gravel pad near the noise source to reduce blast noise. Measurements were conducted to assess this method by detonating C4 charges located over a 15- × 15- × 1.5-m-thick gravel pad or over undisturbed ground and recording the acoustic and seismic waveforms at various distances from the source. The measurements recorded by ERDC-CRREL personnel at propagation distances from 10 to 400 m are documented in this report. Additional reports documenting the longer distance measurements and analyzing the measurements are planned.

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Preface

This report was prepared by Frank E. Perron Jr., Stephen N. Decato, Dr. Donald G. Albert, and David L. Carbee, Geophysical Sciences Branch, Cold Regions Research and Engineering Laboratory, U.S. Army Engineer Research and Development Center.

The participating parties involved in the study are—from the U.S. Army Engineer Research and Development Center (ERDC)—the Construction Engineering Research Laboratory (CERL), Champaign, IL, and the Cold Regions Research and Engineering Laboratory (CRREL), Hanover, NH, and—from the Netherlands—the Netherlands Ministry of Defense (MOD-NL), via the Defense Coordinator for Spatial Planning and Environment (CROMD), and the Netherlands Organization for Applied Scientific Research (TNO).

Many personnel contributed to the success of this test program. Gary Leadore (ATC) was the Test Director, Danny Deal, Range Manager, and Martha Turnbaugh (ATC) Assistant Test Director for the site preparation and during the test measurements. ERDC-CERL participants were Larry Pater, Jeff Miffin, and Samantha Rawlings. ERDC-CRREL participants were Don Albert, Frank Perron, Steve Decato, and Dave Carbee. The Netherlands participants were Frank van den Berg, Jaap van’t Hof, and Frits Van der Eerden, TNO, and Erik van Arkel, MOD-NL. Additional staff from ATC were Billy White, demolitions; Joe Ulrich, photographer; Tom Ruffing and Mark Lang, Surveying; Kevin Bannigan, Jason Eyler, Sgt. Kone, and SPC Hamlin, site support personnel. The authors thank all of them for assistance during the tests, and they thank Dr. Larry Pater of CERL for funding their participation in this study.

This report was prepared under the general supervision of Janet Hardy, Chief, Geophysical Sciences Branch; Lance Hansen, Acting Deputy Director; and James Wuebben, Acting Director, CRREL. The Commander and Executive Director of the Engineer Research and Development Center is COL Richard B. Jenkins. The Director is Dr. James R. Houston.

1 Introduction

The growth of civilian populations near Army training facilities has led to increasing complaints about Army training noise, especially the noise produced by artillery fire. Many approaches are being considered to reduce the noise complaints. This report documents the seismic and acoustic measurements made by CRREL personnel during a joint test of one possible approach, the use of a gravel pad to reduce blast noise. These measurements were conducted to determine the absorbing effect of a 15- by 15- by 1.5-m-thick gravel pad (Figure 1) on detonated single brick M112 C-4 charges. The tests were conducted on the TW Range at the Aberdeen Test Center (ATC), located in Aberdeen, MD, from 13 to 17 June 2005.

2 Approach

This test was to determine whether the blast absorber approach can provide a significant reduction (at least 3 dB) in blast noise at realistic distances from the source. If successful, further development of this method is planned. The concept of the blast absorber approach is to modify a surface near the source of the blast waves to reduce the amount of blast wave energy propagating intothe far field. By using a source above an absorbing surface, the energy reflected from the ground is reduced. Because a rigid ground surface enhances the sound level by 6 dB, reducing or eliminating this energy can potentially have a significant impact on sound levels. Also, by shielding a source with an absorbing surface, blast wave energy is absorbed.

A previous ERDC research project showed that a gravel pit beneath the source location could reduce the sound levels produced by small explosions (Attenborough et al. 2003). However, there were some inconsistencies in these tests, and the tests did not include measurements at longer distances that would be important in practice. In addition, a better design of the blast absorber might provide additional attenuation. This field test was designed to answer these remaining questions.

The previous project was concerned primarily with developing theoretical and computational methods to understand and predict blast absorption from granular materials at high acoustic pressures. The absorption pit sizes were limited by cost, and were not optimized to reduce low frequency blast noise. The gravel pit used in the earlier measurements was 3.66 × 3.66 m, 1.5 m deep (12 × 12 × 5 ft deep) and filled with either three-layered gravel or a uniform gravel layer. The pit with a uniform 0.9-cm gravel size seemed to produce a greater reduction in blast noise that the pit with three layers.

To improve the absorber performance at low frequencies, the size of the gravel pit used for blast absorption must be increased to roughly a wavelength in size. Because a single brick charge of C-4 typically has a peak frequency of 30–50 Hz, the wavelength is roughly 8–12 m. Thus, this study chose a 50- × 50-ft (approximately 15- × 15-m) size for the gravel pit. Because of the presence of unexploded ordinance on the test range, it was not possible to dig a pit and fill it with gravel. Instead a pile of gravel, 1.5-m high with steep edges of approximately 45°, was constructed instead of creating a pit in the ground. As the previous measurements

showed a large reduction (40 dB) in the blast wave after penetration to a depth of 0.5 m, we also specified a depth of 5 ft (1.5 m) for the pad as it will be enough to significantly reduce any reflections from the bottom of the pad. Coarse gravel (3 cm) was used to create the pad and a variety of source locations were used for comparison (Figures 1 and 2).

Figure 1. The 1.5-m-height gravel pad.

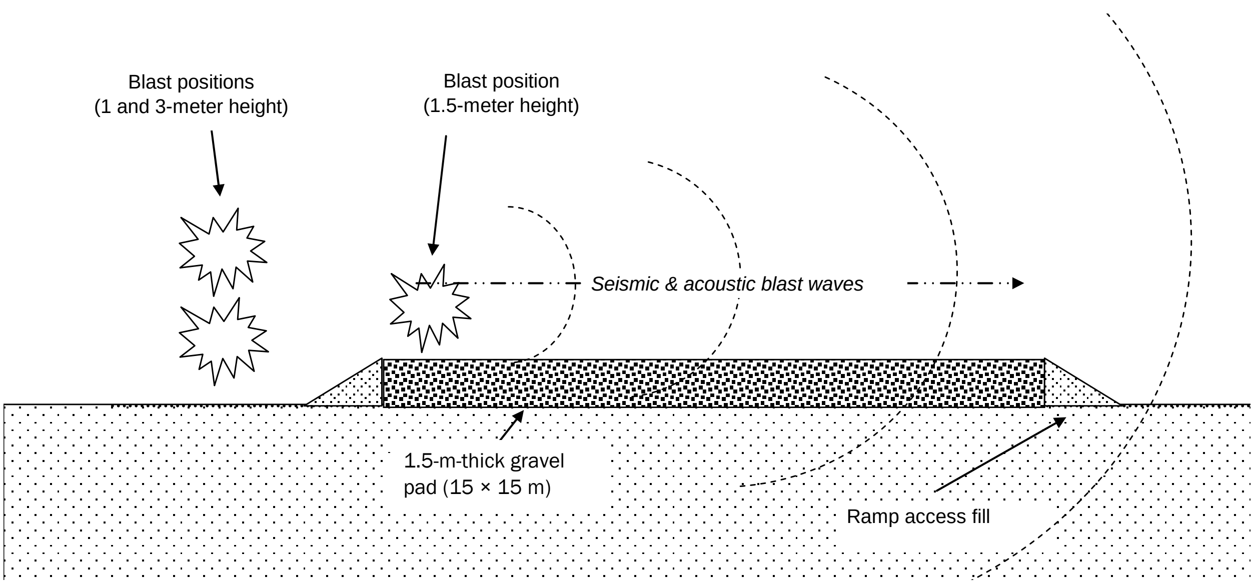


Figure 2. Locations of C-4 blast positions on the gravel pad array.

3 Instrumentation Sensor Array

Two different sensor arrays were used. To determine the effect of the blast absorber at relatively short propagation distances, ERDC-CRREL installed an array of 36 sensors located from 12 to 400 m away from the source locations (Figure 3). The origin (reference point) is even with the back side of the gravel pad, in line with the gravel pad array. Because of the test geometry, two different pressure sensors were installed to record the noise levels at the closest distances, one for each source location. For distances greater than 100 m, the same sensors were used at each distance. The closest sensor locations at 12, 22, and 32 m have pressure sensors only, as the ground motion sensors would be overdriven and would not produce valid data. Beyond 32 m, each sensor location had two pressure sensors (microphones), one at the ground surface and one a 1.5-m height, and two geophones to measure the vertical and horizontal ground motions. The linear sensor array provided measurements at distances of 32, 62, 92, 120, 180, 240, 340, 370 and 400 m from each source location.

The second sensor array (ERDC-CERL) was used to determine the blast noise at longer, more realistic distances of 1.8, 3.2 and 4.5 km. These measurements will be discussed in a separate report.

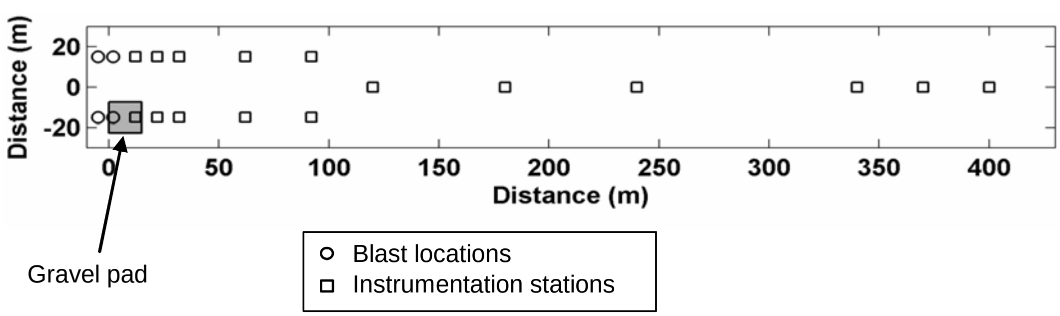


Figure 3. ERDC-CRREL instrumentation array and C-4 detonation locations.

All the shot points and sensor stations locations are presented in Table 1. All measurements are in meters. Table 2 gives information about the ERDC-CRREL sensor array, while Figure 4 shows a typical instrumentation station.

Table 1. Survey coordinates of shot points and sensor stations.

TW #1 Blast Absorber Test
Coordinate System: UTM
Datum: NAD83
Units: Meters

North	East	Description	Grid N	Grid E	Distance	2 mL	2 mR	-5 mL	-5 mR
4368677.645	402583.301	"0" REF	0.0	0.0	0.0	15.2	15.1	15.8	15.8
4368673.932	402598.677	-5 m bare gnd.	-3.7	15.4	15.8	7.0	30.8	**0.0**	30.0
4368668.001	402594.991	2 m bare gnd.	-9.6	11.7	15.2	**0.0**	30.0	7.0	30.8
4368663.758	402592.347	7 m bare gnd	-13.9	9.0	16.6	5.0	30.4	12.0	32.3
4368659.525	402589.700	12 m bare gnd.	-18.1	6.4	19.2	10.0	31.6	17.0	34.5
4368651.036	402584.395	22 m bare gnd.	-26.6	1.1	26.6	20.0	36.1	27.0	40.4
4368642.556	402579.094	32 m bare gnd.	-35.1	-4.2	35.3	30.0	42.4	37.0	47.6
4368617.078	402563.229	62 m bare gnd.	-60.6	-20.1	63.8	60.0	67.1	67.0	73.5
4368591.630	402547.348	92 m bare gnd.	-86.0	-36.0	93.2	90.0	94.9	97.0	101.6
4368607.501	402521.883	92 m gravel pad	-70.1	-61.4	93.2	94.9	90.0	101.5	97.0
4368632.952	402537.755	62 m gravel pad	-44.7	-45.5	63.8	67.1	60.0	73.4	67.1
4368658.424	402553.640	32 m gravel pad	-19.2	-29.7	35.3	42.4	30.0	47.6	37.0
4368666.898	402558.948	22 m gravel pad	-10.7	-24.4	26.6	36.1	20.0	40.3	27.0
4368675.408	402564.232	12 m gravel pad	-2.2	-19.1	19.2	31.6	10.0	34.5	17.0
4368679.641	402566.890	7 m gravel pad	2.0	-16.4	16.5	30.4	5.0	32.3	12.0
4368683.893	402569.523	2 m gravel pad	6.2	-13.8	15.1	30.0	**0.0**	30.8	7.0
4368689.843	402573.246	-5 m gravel pad	12.2	-10.1	15.8	30.8	7.0	30.0	**0.0**
4368569.529	402515.876	120 m	-108.1	-67.4	127.4	126.3	126.3	133.3	133.3
4368524.931	402488.029	180 m	-152.7	-95.3	180.0	178.6	178.6	185.6	185.6
4368467.713	402452.364	240 m	-209.9	-130.9	247.4	245.9	245.9	252.9	252.9
4368382.869	402399.438	340 m	-294.8	-183.9	347.4	345.7	345.8	352.7	352.8
4368363.386	402387.299	370 m	-314.3	-196.0	370.4	368.7	368.7	375.7	375.7
4368337.850	402371.359	400 m	-339.8	-211.9	400.5	398.8	398.8	405.7	405.8
4368252.771	402318.232	500 m	-424.9	-265.1	500.8	499.0	499.0	506.0	506.0
4367826.416	402052.341	1000 m	-851.2	-531.0	1003.2	1001.4	1001.4	1008.3	1008.4
4367152.301	401536.859	1845 m	-1525.3	-1046.4	1849.8	1848.5	1847.2	1855.5	1854.2
4365918.666	400925.926	3218.5 m	-2759.0	-1657.4	3218.5	3216.3	3216.8	3223.3	3223.8
4364792.940	400394.874	4458.7 m	-3884.7	-2188.4	4458.7	4456.1	4457.4	4463.1	4464.4

Table 2. ERDC-CRREL sensor array.

a. Cable #1, 30-m array cable (four takeouts every 30 m), from gravel pad source location (at +2 m).

Station	Channel	Sensor	S/N	Location (m)	Height (cm)
1	12	PCB 102A06	15962	12	10.2
1	11	PCB 102A06	15964	22	152.4
1	10	PCB 102A09	15969	32	152.4
1	9	PCB 102A09	15968	32	12.7
2	8	PCB 102A07	15971	62	152.4
2	7	PCB 102A07	15973	62	16.5
2	6	V geophone		62	0
2	5	H geophone		62	0
3	3	PCB 106B50	6522	92	152.4
3	4	PCB 106B50	6693	92	10.8
3	2	V geophone		92	0
3	1	H geophone		92	0

Table 2 (cont'd). ERDC-CRREL sensor array.

b. Cable #2, 30-m array cable (four takeouts every 30 m), from bare ground source location.

Station	Channel	Sensor	S/N	Location (m)	Height (cm)
4	24	PCB 102A06	15965	12	8.9
4	23	PCB 102A06	15966	22	142.2
4	22	PCB 102A09	15970	32	148.6
4	21	PCB 102A09	13180	32	15.2
5	20	PCB 102A07	15972	62	151.1
5	19	PCB 102A07	15974	62	9.5
5	18	V geophone		62	0
5	17	H geophone		62	0
6	16	PCB 106B50	6695	92	152.4
6	15	PCB 106B50	3259	92	16.5
6	14	V geophone		92	0
6	13	H geophone		92	0

c. Cable #3, 60-m interval between every four takeouts. Set attenuation factor to 1/10 (–20 dB) for all B&K microphones on this cable.

Station	Channel	Sensor	S/N	Location (m)	Height (cm)
7	36	B&K 4938-1	2239253	120	152.4
7	35	B&K 4938-2	2239254	120	25.4
7	34	V geophone		120	0
7	33	H geophone		120	0
8	32	B&K 4938-3	2239255	180	152.4
8	31	B&K 4938-4	2239256	180	25.4
8	30	V geophone		180	0
8	29	H geophone		180	0
9	28	B&K 4938-5	2239257	240	150
9	27	B&K 4938-6	2239258	240	25.4
9	26	V geophone		240	0
9	25	H geophone		240	0

Table 2 (cont'd). ERDC-CRREL sensor array.

d. Cable #4, 200-m interval between every four takeouts. Set attenuation factor to 1/100 (-40 dB) for all B&K microphones on this cable.

Station	Channel	Sensor	S/N	Location (m)	Height (cm)
10	37	B&K 4165-7	1881046	340	150
10	47	B&K 4165-8	1881049	340	0
10	46	V geophone		340	0
10	45	H geophone		340	0
11	44	B&K 4165-9	1881050	370	150
11	43	B&K 4165-10	2068999	370	0
11	42	V geophone		370	0
11	41	H geophone		370	0
12	40	B&K 4165-5	1857589	400	150
12	39	B&K 4165-6	1881043	400	0
12	38	V geophone		400	0
12	37	H geophone		400	0

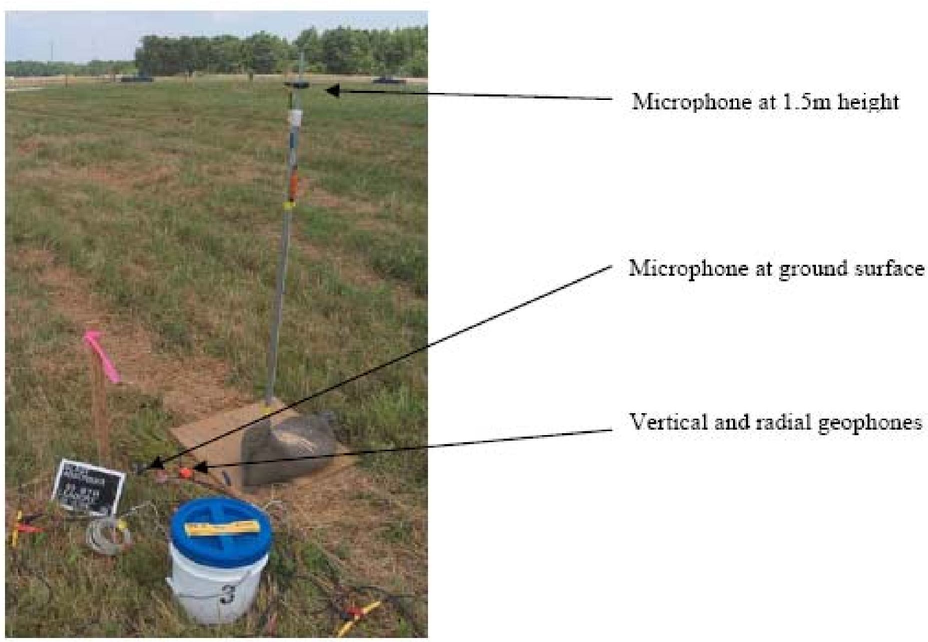


Figure 4. Instrumentation Station 6 at 90 m.

4 Recorded Events

Data was recorded on a digital StrataVisor (Figure 5 and Table 3) NZ Exploration Seismic Recorder (Appendix B), with 48 channels and 0.03125 ms sampling interval.

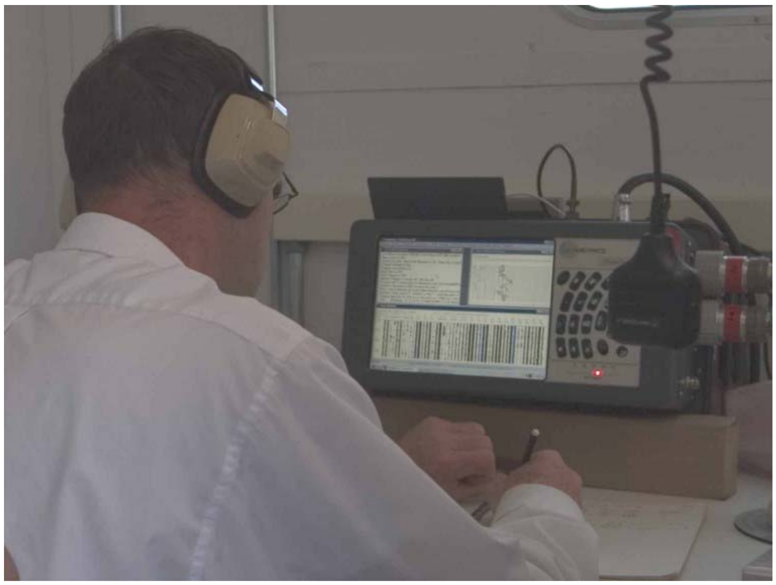


Figure 5. StrataVisor NZ seismograph recorder.

Table 3. StrataVisor Geometric Model NZ seismograph specifications.

Number of channels	48
Digitization (bits)	24
Sampling rate	0.03125 ms
Frequency band	1.75 Hz – 20 kHz (–3dB at 83% Nyquist, Down 90 dB at Nyquist)
Maximum signal voltage	±1.4 V at 0 dB
Maximum record length	65k
Noise floor, μV RMS	0.2
Pretrigger	4096 samples
Operating temperature	+5°C start-up, –5°C operation

Records were obtained for thirty-three C-4 detonations, twenty .45-caliber blank pistol shots and six detonated blasting caps. Numerous noise records and microphone calibration records were also taken. Only the C-4, pistol, and blasting cap records are presented in this report.

C-4 Recorded Events.

Thirty-three single brick M112 C-4 charges were detonated at six different shot points. The bricks weigh 1.25 lb (0.57 kg) and were detonated above the ground by suspending them from a cross line between two poles (Figure 6).

Figure 6. C-4 brick being suspended at 1.5 m above the gravel pad.

The different shot point locations were identified by a code of the form Type + Distance + Height. Here, Type is a letter code denoting whether the shot was near the absorber or not. P is the letter used to specify the gravel **p**ad, while B indicates that the shot was over **b**are ground. The Distance is given by a number, either +2 or –5. This is the *x* grid coordinate in meters, with 0 being the back edge of the gravel pad. Finally, H is the height of the source above the ground or gravel pad in meters (Figure 7). Table 4 lists the events.

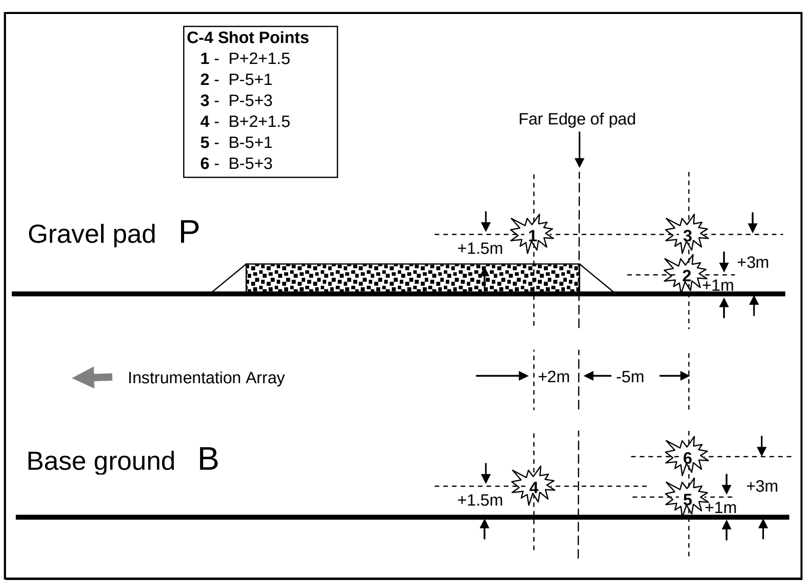


Figure 7. Locations of the six C-4 shot points.

Table 4. C-4 recorded events (shot records).

CRREL Binary File No.	CERL Shot No.	Date	Time (EST)	Source	Source Location	Source Height (m)	Remarks
37	1	15-Jun	13:46	C4	B-5+3		Ch 21 & 15 bad, 18, 11 & 12 have crosstalk
38	2	15-Jun	14:42	C4	B+2+1.5		
39	3	15-Jun	14:34	C4	P+2+1.5		(FP2 back) Ch 11 & 12 timebreak crosstalk, Ch 21 & 15 bad
40	4	15-Jun	15:55	C4	B+2+1.5		(FP1 back) Ch 21 bad
41		15-Jun		Noise record			
42	5	15-Jun	15:58	C4	P+2+1.5		(FP2 back) Ch 21 bad. Swapped out Ch21 w/102A06, s/n 16784, 30m
43	6	15-Jun	16:31	C4	B-5+3		Good record, all channels
44	7	15-Jun	16:33	C4	P-5+3		Good record, all channels except 11 & 12
45	8	15-Jun	16:55	C4	B-5+3		Cross talk on 16
46	9	15-Jun	16:57	C4	P-5+3		Cross talk on 18, 12 looks noisy
68		16-Jun	9:39	Noise record			
69	10	16-Jun	9:50	C4	B-5+1		Ch 18 & 15 early crosstalk
70	11	16-Jun	9:52	C4	P-5+1		Ch 18, 15 & 23 crosstalk
71	12	16-Jun	9:45	C4	B-5+1		Ch 18, 15 & 23 crosstalk
72	13	16-Jun	10:11	C4	P-5+1		Ch 18 & 15 crosstalk
		16-Jun	10:15				Moved cable near Ch 18
73	14	16-Jun	10:30	C4	B+5+1.5		Ch 18 & 15 crosstalk
74	15	16-Jun	10:31	C4	P-5+1.5		Ch 18 & 15 crosstalk
75	16	16-Jun	10:46	C4	B+2+1.5		Ch 18 crosstalk
76	17	16-Jun	10:48	C4	P+2+1.5		Ch 18 & 15 crosstalk
77	18	16-Jun	11:01	C4	B+2+1.5		Ch 18 crosstalk, a little on 15
78	19	16-Jun	11:03	C4	P+2+1.5		Ch 18 & 15 crosstalk
79	20	16-Jun	11:18	C4	B+2+1.5		Ch 18 & 15 crosstalk
80	21	16-Jun	11:19	C4	P+2+1.5		Ch 18, 15 & 23 crosstalk
81	22	16-Jun	11:43	C4	B-5+3		Ch 18 crosstalk
82	23	16-Jun	11:45	C4	P-5+3		AQ little crosstalk on Ch 18
83	24	16-Jun	13:53	C4	B-5+3		Good record
84	25	16-Jun	13:54	C4	P-5+3		A little noise on Ch 23
85	26	16-Jun	14:08	C4	B-5+3		All channels good
86	27	16-Jun	14:09	C4	P-5+3		All channels good
87	28	16-Jun	14:25	C4	B-5+1		TD crosstalk on many channels
88	29	16-Jun	14:26	C4	P-5+1		TD crosstalk on many channels
89	30	16-Jun	14:40	C4	B-5+1		Some crosstalk on CH 11, 12. 15, 21 & 23
90	31	16-Jun	14:42	C4	P-5+1		Some crosstalk on CH 15 & 23
91	32	16-Jun	14:55	C4	B-5+1		TD crosstalk on many channels
92	33	16-Jun	14:56	C4	P-5+1		Some crosstalk on multiple channels

Blank Pistol Recorded Events

A .45-caliber blank pistol was held at a height of 1 m and fired along the array to characterize the ground impedance (Figure 8). The blank cartridges used are custom made with an overall length of 22.6 mm, 7.6-g cartridge weight, 5.8-g case weight, with 31 g of FFFFG, CCI black powder. Figure 9 shows location and direction of the blank pistol shots, while Table 5 lists the events.

Figure 8. Blank .45-caliber pistol fired along the sensor array at a 1-m height.

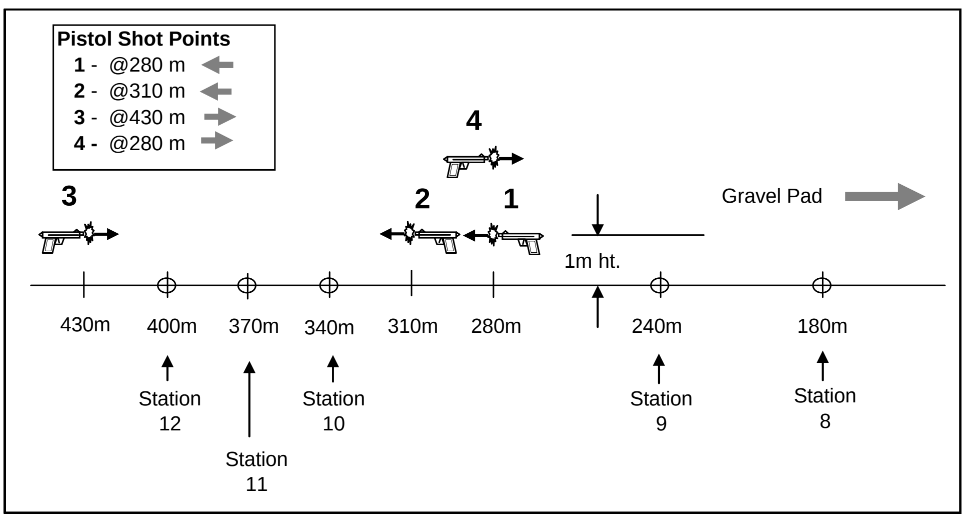


Figure 9. Location and direction of the blank pistol shots.

Table 5. Blank pistol recorded events (shot record).

CRREL Binary File No.	CERL Shot No.	Date	Time (EST)	Source	Source Location	Source Height (m)	Remarks
47		16-Jun	8:19	Noise record			NZ @.125ms, pretrigger -.5sec
48		16-Jun	8:23	Pistol 1	280m, up line	1	Ch 47 & 48 were off
49		16-Jun		Pistol 1	280m, up line	1	
50		16-Jun		Pistol 1	280m, up line	1	
51		16-Jun		Pistol 1	280m, up line	1	
52		16-Jun	8:32	Pistol 1	280m, up line	1	
53		16-Jun		Pistol 2	310m, up line	1	
54		16-Jun		Pistol 2	310m, up line	1	
55		16-Jun		Pistol 2	310m, up line	1	
56		16-Jun		Pistol 2	310m, up line	1	
57		16-Jun		Pistol 2	310m, up line	1	
58		16-Jun		Pistol 3	430m, down line	1	
59		16-Jun	8:45	Pistol 3	430m, down line	1	
60		16-Jun		Pistol 3	430m, down line	1	
61		16-Jun		Pistol 3	430m, down line	1	
62		16-Jun	8:48	Pistol 3	430m, down line	1	
63		16-Jun	8:53	Pistol 4	280m, down line	4	Personnel @ 90m
64		16-Jun		Pistol 4	280m, down line	4	
65		16-Jun		Pistol 4	280m, down line	4	
66		16-Jun		Pistol 4	280m, down line	4	
67		16-Jun	8:57	Pistol 4	280m, down line	4	

Blasting Cap Recorded Events

Six blasting caps were detonated from two different shot points to assist in characterizing the ground impedance and instrumentation response. The caps were suspended above the ground in a manner similar to the C-4 charges. Figure 10 gives the locations of the blasting cap detonations, while Table 6 lists the events.

Table 6. Blasting cap recorded events (shot record).

CRREL Binary File No.	CERL Shot No.	Date	Time (EST)	Source	Source Location	Source Height (m)	Remarks
105		16-Jun	15:38	Noise record			
106	Cap 1	16-Jun	15:44	Blasting cap	P+2+2		
							Switched to 36 channels on NZ
107	Cap 2	16-Jun	15:49	Blasting cap	P+2+2		
108	Cap 3	16-Jun	16:01	Blasting cap	B+2+2		Crosstalk
109	Cap 4	16-Jun	16:25	Blasting cap	B+2+2		Crosstalk
110	Cap 5	16-Jun	16:32	Blasting cap	B+2+2		
111	Cap 6	16-Jun	16:37	Blasting cap	B+2+2		Lots of crosstalk

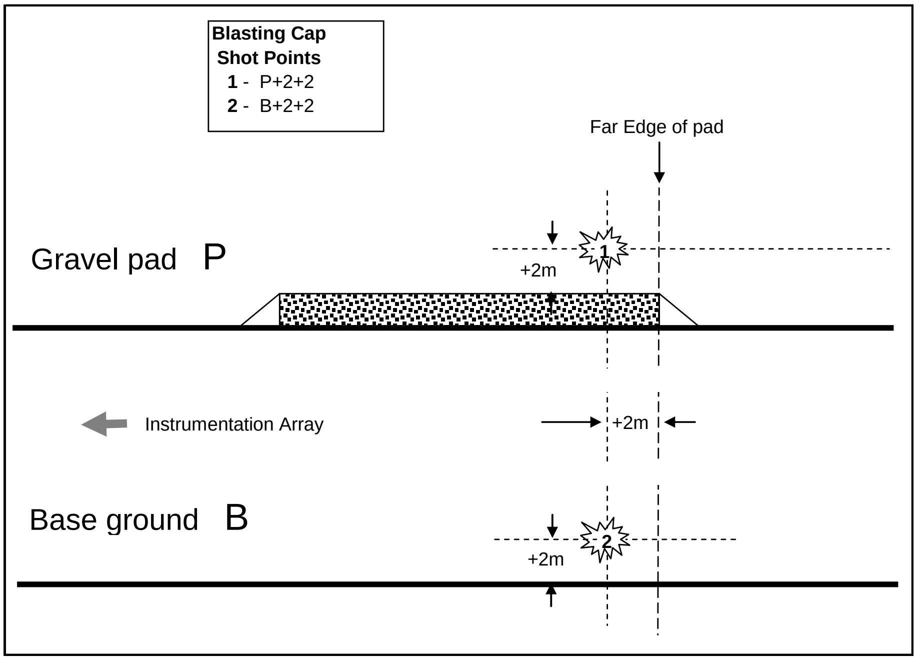


Figure 10. Locations of the blasting cap detonations.

5 Meteorological Measurements During Testing.

The ERDC-CRREL met station (Figure 11), a Hobo model H-08-04-002, was located approximately 10 m off set from Station 7 at 120 m. Measurements of temperature, wind speed, wind gusts, wind direction, atmospheric pressure, and relative humidity were recorded during the three days of testing. Figures 12 and 13 show the meteorological data during the shot testing times on 16 and 17 June. Figure 14 shows the complete 3-day meteorological data over the entire time during shots and calibrations.

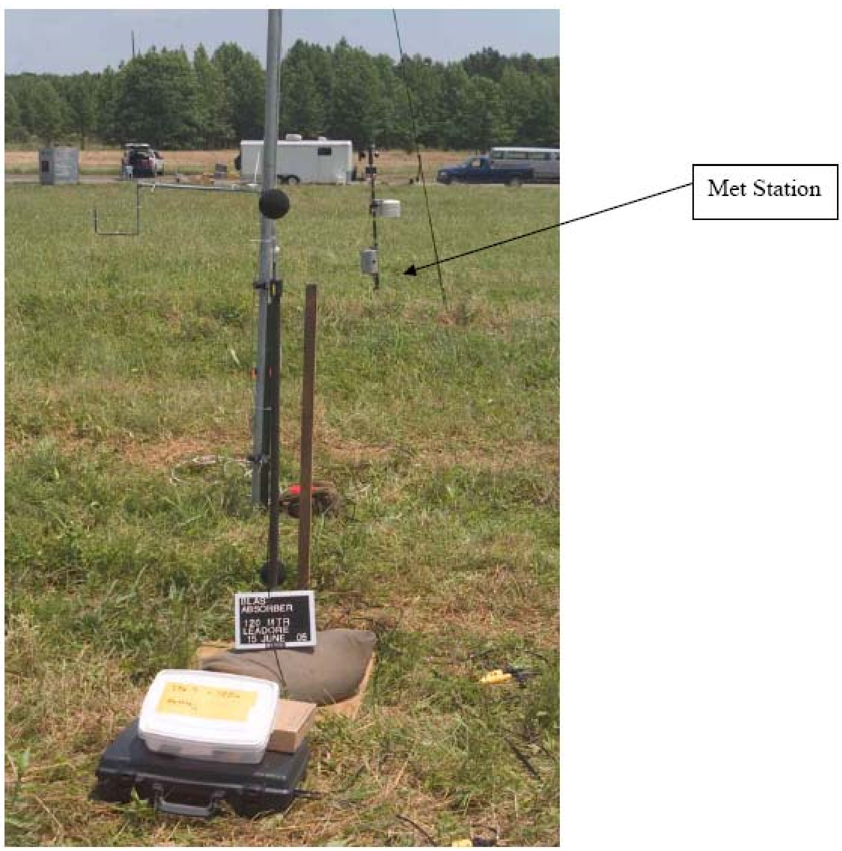


Figure 11. ERDC-CRREL Met Station at 120 m.

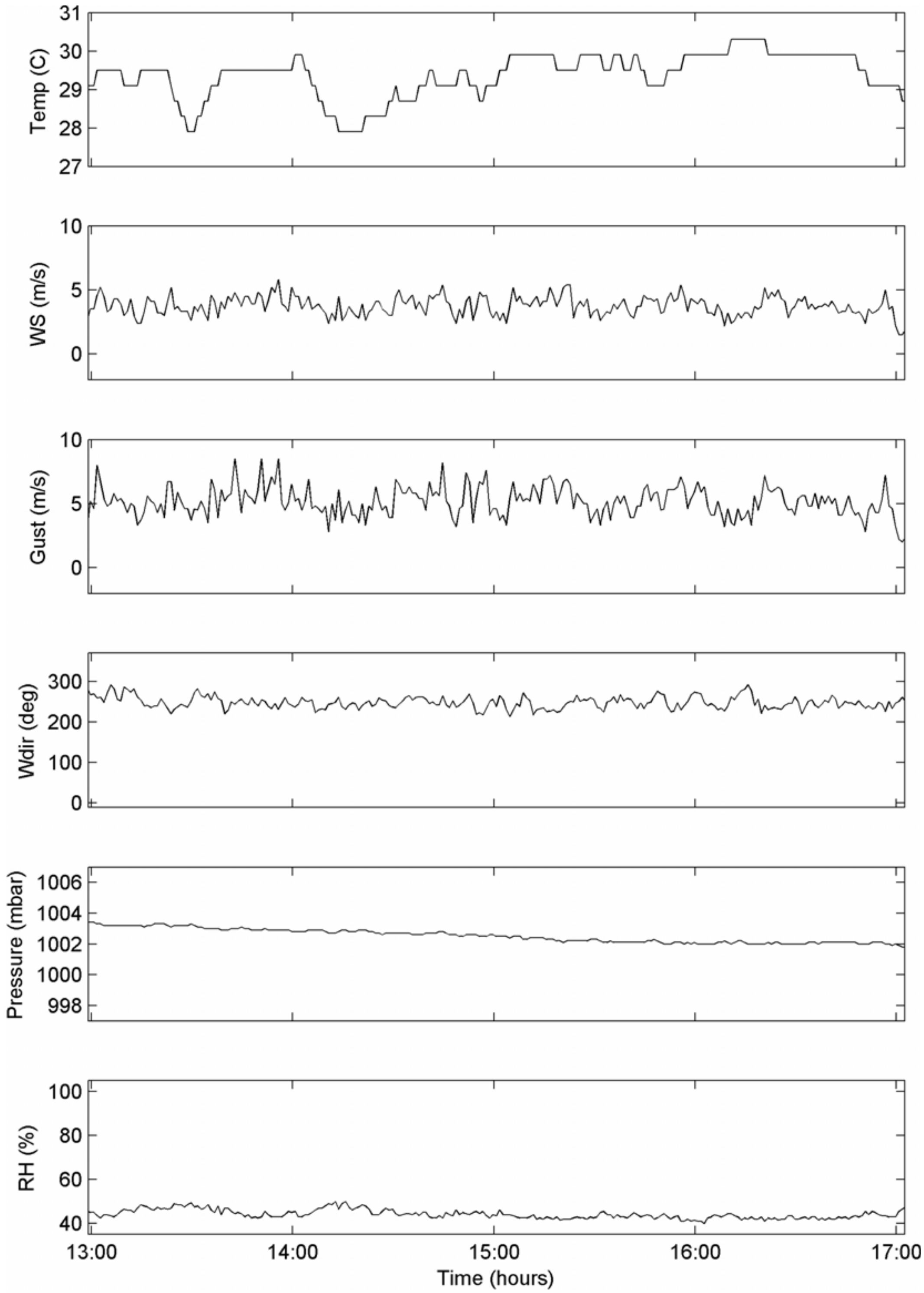


Figure 12. Met data for 15 June test period.

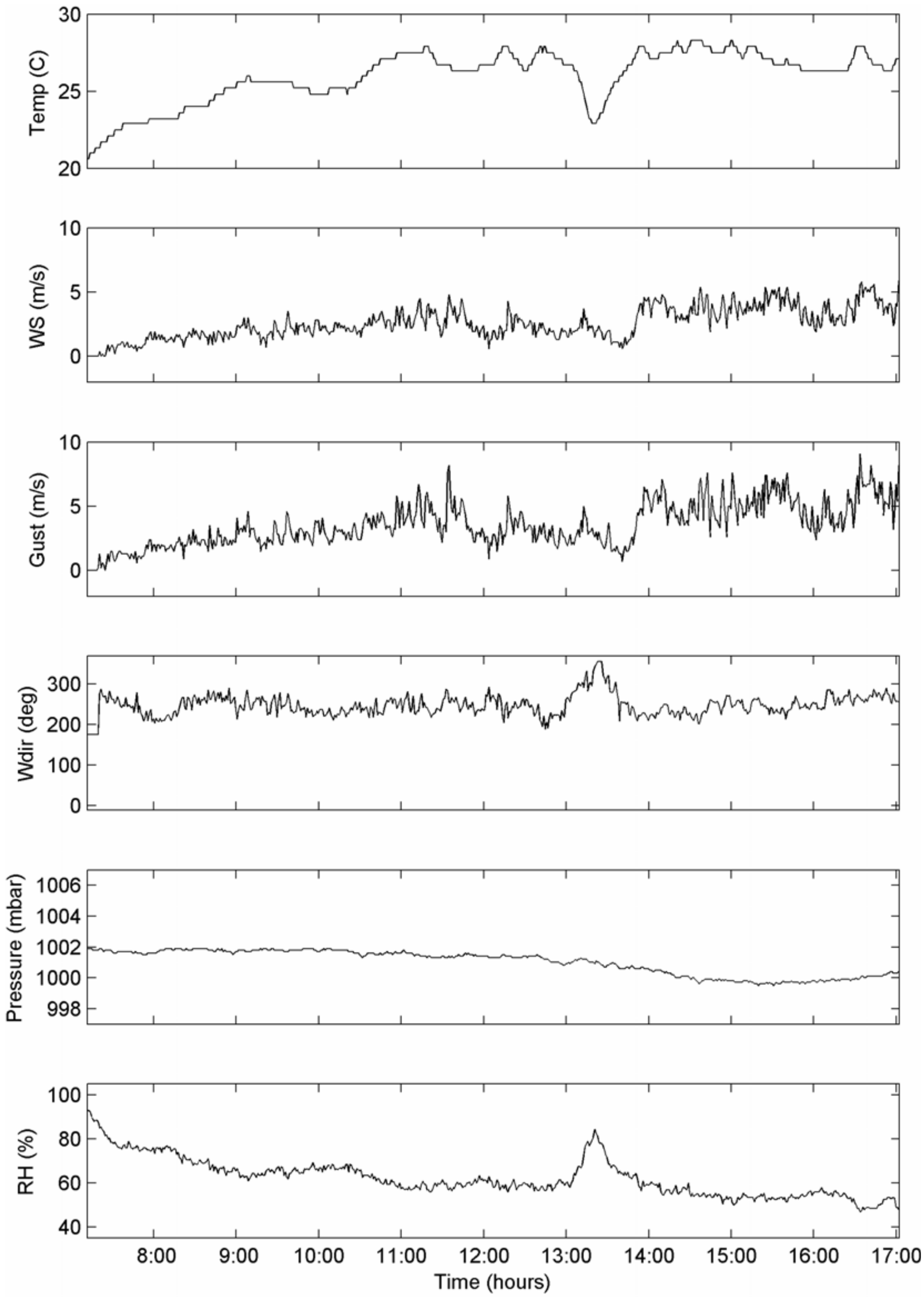


Figure 13. Met data for 16 June test period.

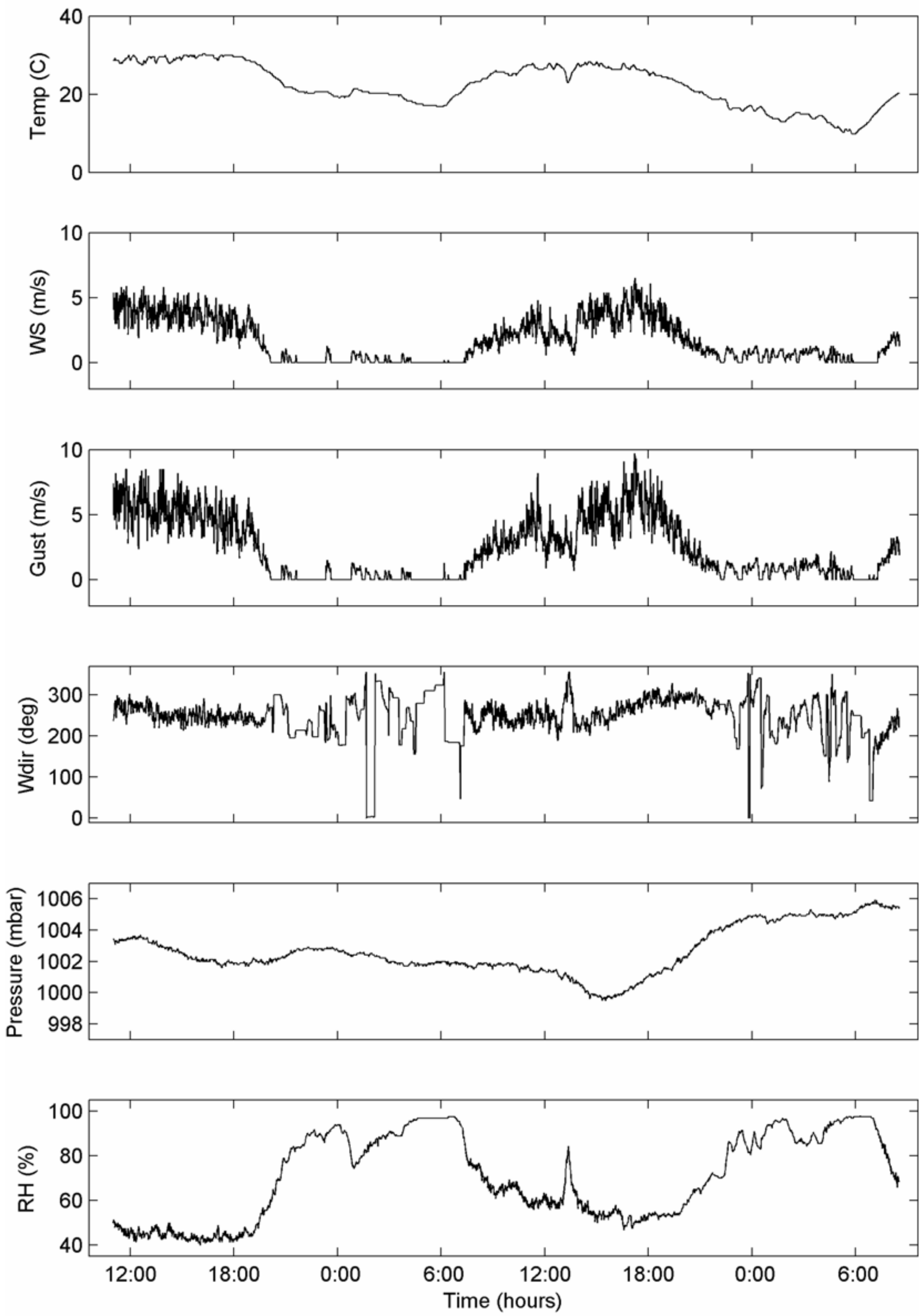


Figure 14. Met data for the entire 3-day testing period.

6 Data Quality, Signature Records, and Data Plots.

Each channel from all the records is evaluated for response, noise, ringing, and crosstalk to determine if that data is usable. The following three Tables 7 through 9 rate each data channel.

Table 7. Pistol sensor data quality.

MD 2005 Blast Absorber Test **Blank Pistol Shots**
Sensors - Channel numbers

Note: Channels 1-24 are bad for all pistol shots

	CRREL Rec Num->	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69
36	P-122-1	X	X	X	X	X	X	X	X	X	X	X	X	X	VN	X	N	N	O	O	O		
35	P-122-0	X	X	X	X	X	X	X	X	X	X	X	X	X	VN	X	N	N	N	VN	N		
34	V-122	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	VN	X	N		
33	R-122	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	VN	VN	N	X	N		
32	P-182-1	VN	VN	VN	VN	VN	X	X	X	X	X	X	VN	VN	VN	VN	O	O	O	O	O		
31	P-182-0	VN	VN	VN	VN	VN	X	X	X	X	X	X	VN	VN	VN	VN	O	O	O	O	O		
30	V-182	VN	VN	VN	VN	VN	X	X	X	X	X	X	X	X	X	X	N	N	O	N	O		
29	R-182	VN	VN	VN	VN	VN	X	X	X	X	X	X	X	X	X	X	N	N	O	N	O		
28	P-242-1	O	O	O	O	O	VN	VN	VN	VN	VN	VN	VN	VN	VN	VN	O	O	O	O	O		
27	P-242-0	O	O	O	O	O	VN	VN	VN	VN	VN	VN	VN	VN	VN	VN	O	O	O	O	O		
26	V-242	VN	VN	VN	VN	VN	X	X	X	X	X	X	X	X	X	X	O	O	O	O	O		
25	R-242	N	N	N	N	N	X	X	X	X	X	X	X	X	X	X	O	O	O	O	O		
48	P-342-1	X	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	VN		
47	P-342-0	X	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	N		
46	V-342	O	O	O	O	O	O	O	O	O	O	O	O	N	O	O	N	N	N	N	N		
45	R-342	O	N	N	N	N	O	O	O	O	O	N	O	N	N	N	VN	VN	VN	VN	VN		
44	P-372-1	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	N	N	N	N	N		
43	P-372-0	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	N	N	N	N	N		
42	V-372	O	O	O	O	O	O	O	O	O	O	O	O	N	O	O	N	N	N	VN	VN		
41	R-372	O	O	O	O	O	O	O	O	N	O	N	O	N	N	N	N	X	VN	VN	VN		
40	P-402-1	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	VN	VN	VN	VN	N		
39	P-402-0	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	VN	VN	VN	VN	N		
38	V-402	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	VN	VN	VN	VN	VN		
37	R-402	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	VN	X	VN	VN	VN		
1-12		ALL CHANNELS BAD ON ALL PISTOL SHOTS																					
13-24		ALL CHANNELS BAD ON ALL PISTOL SHOTS																					

O = Good
X = Bad
N = Noisy data - but usable
R = Ringing sensor
C = Crosstalk
VN = Very Noisy data - arrival visible but not usable without add'l processing

Table 8. C-4 sensor data quality.

MD 2005 Blast Absorber Test C-4 Shots
Sensors - Channel numbers

	CERL Shot Num ->	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
	CRREL Rec Num->	37	38	39	40	42	43	44	45	46	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92
	Source Location ->	B	B	P	B	P	B	P	B	P	B	P	B	P	B	P	B	P	B	P	B	P	B	P	B	P	B	P	B	P	B	P	B	P
12	PP-12-0	X	X	X	X	X	X	X	X	X	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
11	PP-22-1	X	X	X	X	X	X	X	X	X	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
10	PP-32-1	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
9	PP-32-0	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
8	PP-62-1	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
7	PP-62-0	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
6	VP-62	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
5	RP-62	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
4	PP-92-1	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	N	O	O	O	O	O	O	O	O	O	O	O	O	O
3	PP-92-0	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
2	VP-92	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
1	RP-92	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
24	PB-12-0	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
23	PB-22-1	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
22	PB-32-1	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
21	PB-32-0	X	X	X	X	X	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
20	PB-62-1	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
19	PB-62-0	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	N	O	O	O	O	O	O
18	VB-62	X	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
17	RB-62	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
16	PB-92-1	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
15	PB-92-0	X	X	X	O	C	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	C	C	C	C	C	O	N	O	O	N	N	N	O
14	VB-92	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
13	RB-92	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
36	P-122-1	O																																
35	P-122-0	O																																
34	V-122	O																																
33	R-122	O																																
32	P-182-1	O		ALL CHANNELS GOOD ON ALL SHOTS																														
31	P-182-0	O																																
30	V-182	O																																
29	R-182	O																																
28	P-242-1	O																																
27	P-242-0	O																																
26	V-242	O																																
25	R-242	O																																
48	P-342-1	O																																
47	P-342-0	O																																
46	V-342	O																																
45	R-342	O																																
44	P-372-1	O		ALL CHANNELS GOOD ON ALL SHOTS																														
43	P-372-0	O																																
42	V-372	O																																
41	R-372	O																																
40	P-402-1	O																																
39	P-402-0	O																																
38	V-402	O																																
37	R-402	O																																

O = Good
X = Bad
N = Noisy data - but usable
R = Ringing sensor
C = Crosstalk

Table 9. Blasting cap sensor data quality.

MD 2005 Blast Absorber Test **Blasting caps**
Sensors - Channel numbers

	CRREL Rec Num->	106	107	108	109	110	111
12	PP-12-0	O	O	O	X	X	X
11	PP-22-1	VN	N	N	X	X	X
10	PP-32-1	O	O	O	VN	VN	O
9	PP-32-0	VN	O	O	VN	VN	N
8	PP-62-1	VN	O	O	X	X	X
7	PP-62-0	O	O	O	VN	VN	VN
6	VP-62	O	O	O	O	O	N
5	RP-62	O	O	O	O	O	N
4	PP-92-0	VN	N	O	N	VN	X
3	PP-92-1	N	O	O	X	X	X
2	VP-92	O	O	O	O	O	N
1	RP-92	O	O	O	O	O	N
24	PB-12-0	X	X	VN	O	N	N
23	PB-22-1	X	X	N	N	VN	N
22	PB-32-1	X	X	VN	N	N	N
21	PB-32-0	X	X	X	X	X	VN
20	PB-62-1	X	X	VN	VN	X	X
19	PB-62-0	X	X	VN	X	VN	X
18	VB-62	O	O	O	O	O	N
17	RB-62	O	O	O	O	O	O
16	PB-92-1	O	N	O	VN	VN	VN
15	PB-92-0	VN	N	N	VN	VN	X
14	VB-92	O	N	O	O	O	N
13	RB-92	O	O	O	O	O	N
36	P-122-1	N	N	N	N	N	VN
35	P-122-0	N	N	N	N	N	VN
34	V-122	N	O	O	O	N	N
33	R-122	N	N	O	O	N	X
32	P-182-1	VN	O	O	O	X	N
31	P-182-0	VN	O	O	O	X	N
30	V-182	O	O	O	O	X	O
29	R-182	O	O	O	O	X	O
28	P-242-1	X	VN	N	VN	VN	X
27	P-242-0	X	VN	N	N	VN	X
26	V-242	X	VN	N	N	VN	X
25	R-242	X	VN	N	N	VN	X

O = Good
X = Bad
N = Noisy data - but usable
R = Ringing sensor
C = Crosstalk
VN = Very Noisy data - arrival visible but not usable without add'l processing

Note: Channels 36-48 were off during these recordings (except record 106, bad)
108: Cross-talk interference on all channels - muting needed
112: Strong time break cross-talk on all channels

The following signal data plots show the response of the sensors recorded (48 for C-4 and the blasting caps and 24 for the pistol) during each test. The plots are normalized so that each channel is the same size. The maximum amplitude (in Pa for pressure sensors, m/s for geophones) is shown in the label for each channel. Figures 15 through 17 describe the plot layout, labels, and descriptions for the C-4, pistol, and blasting cap plots.

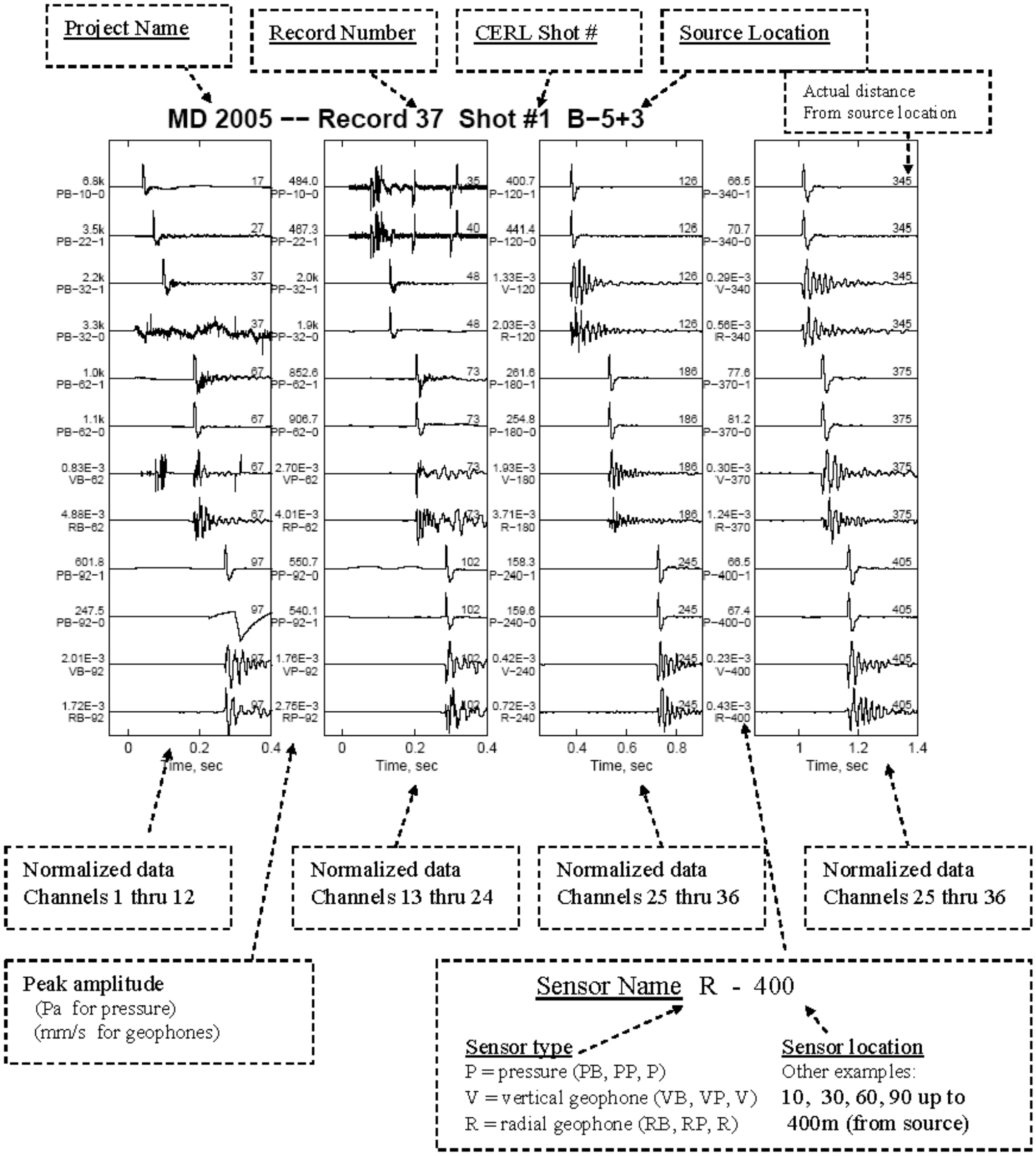


Figure 15. Description of C-4 data plots.

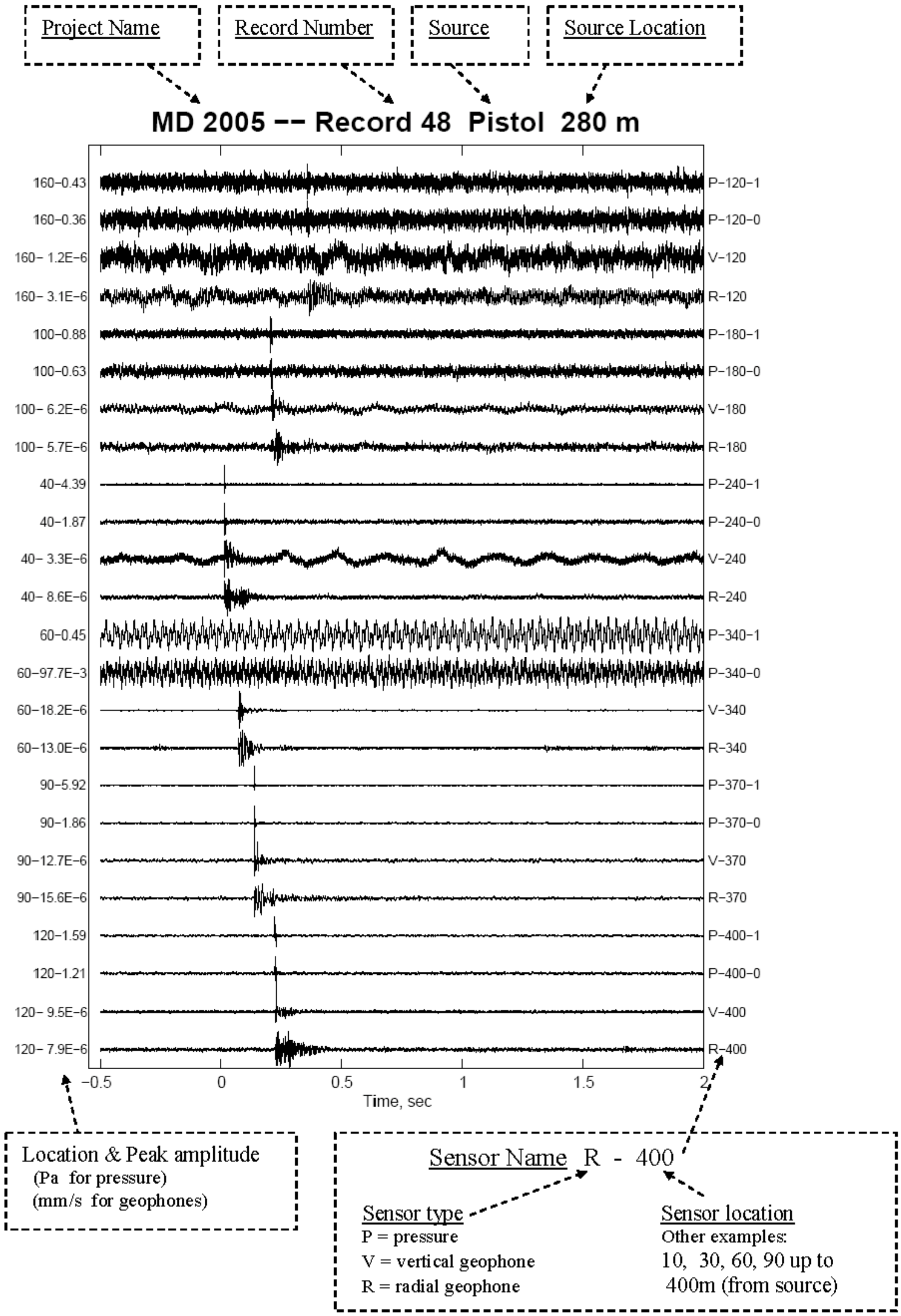


Figure 16. Description of pistol data plots.

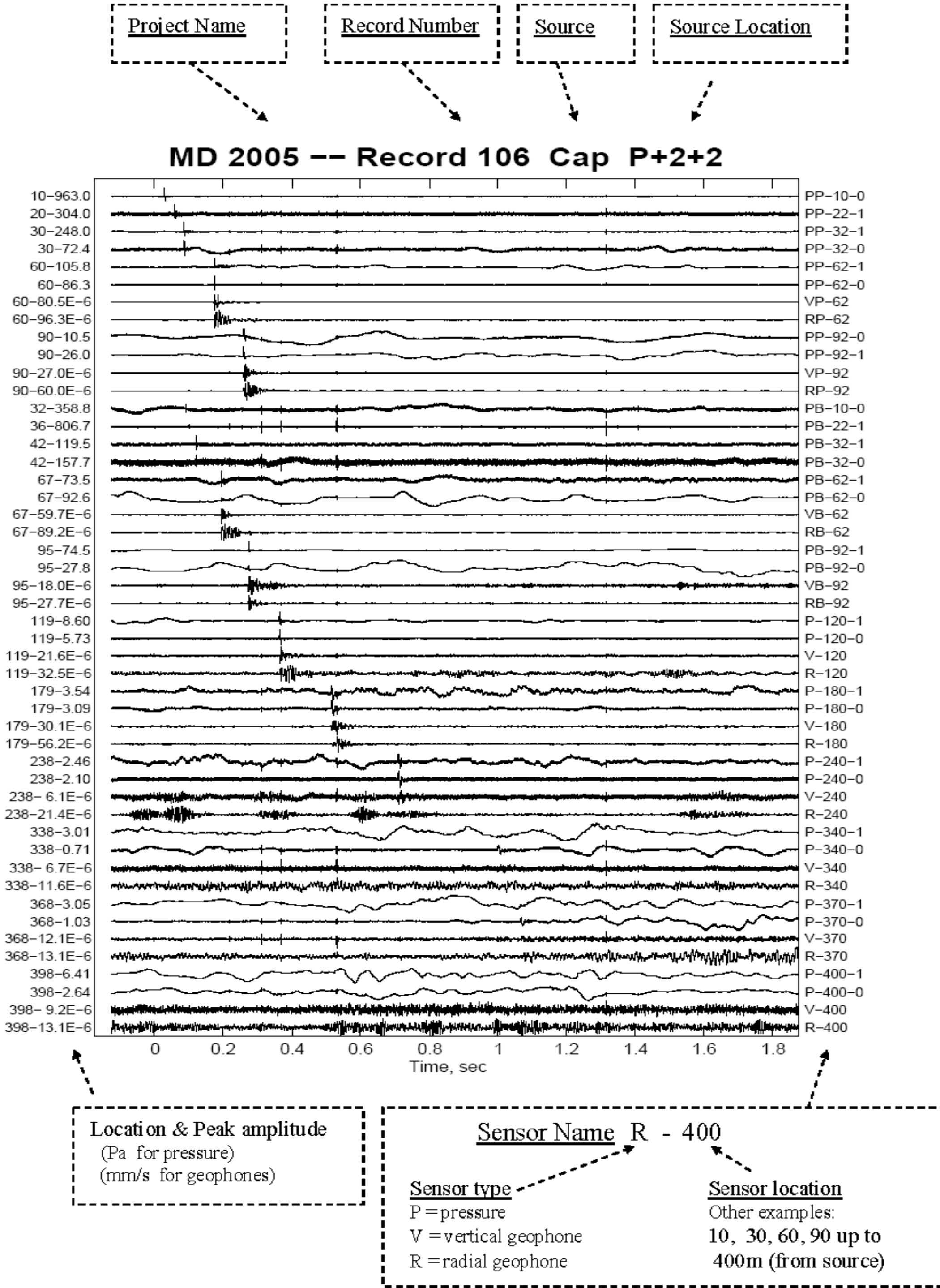
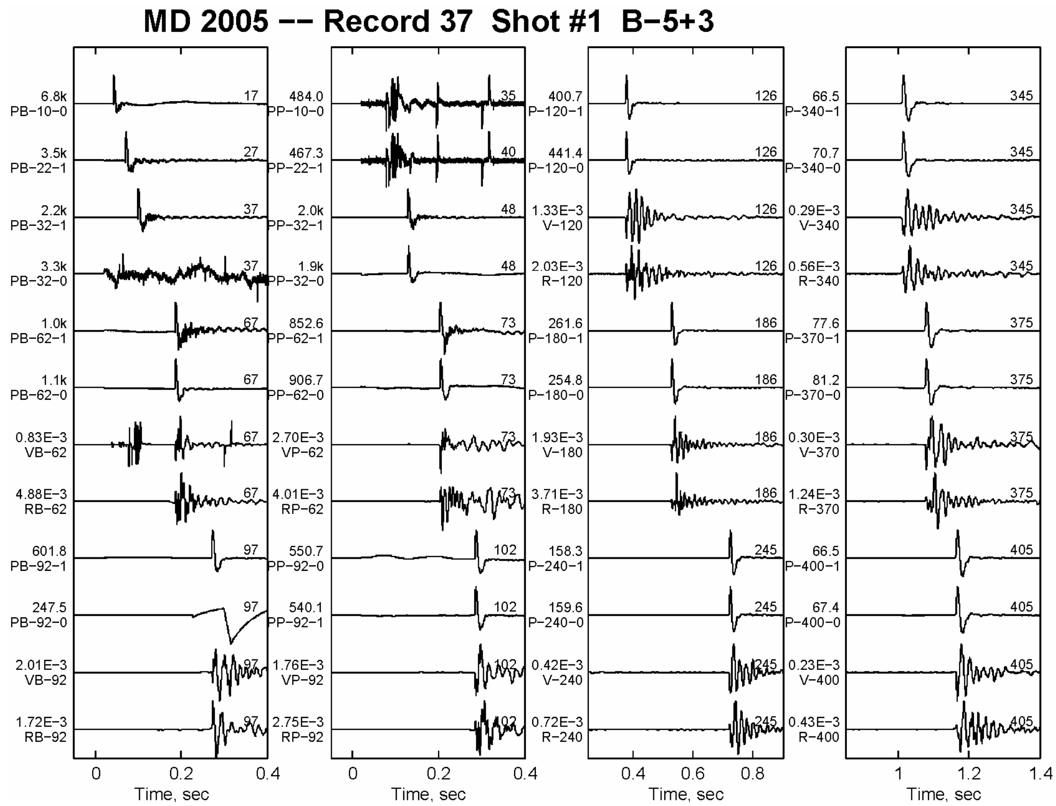
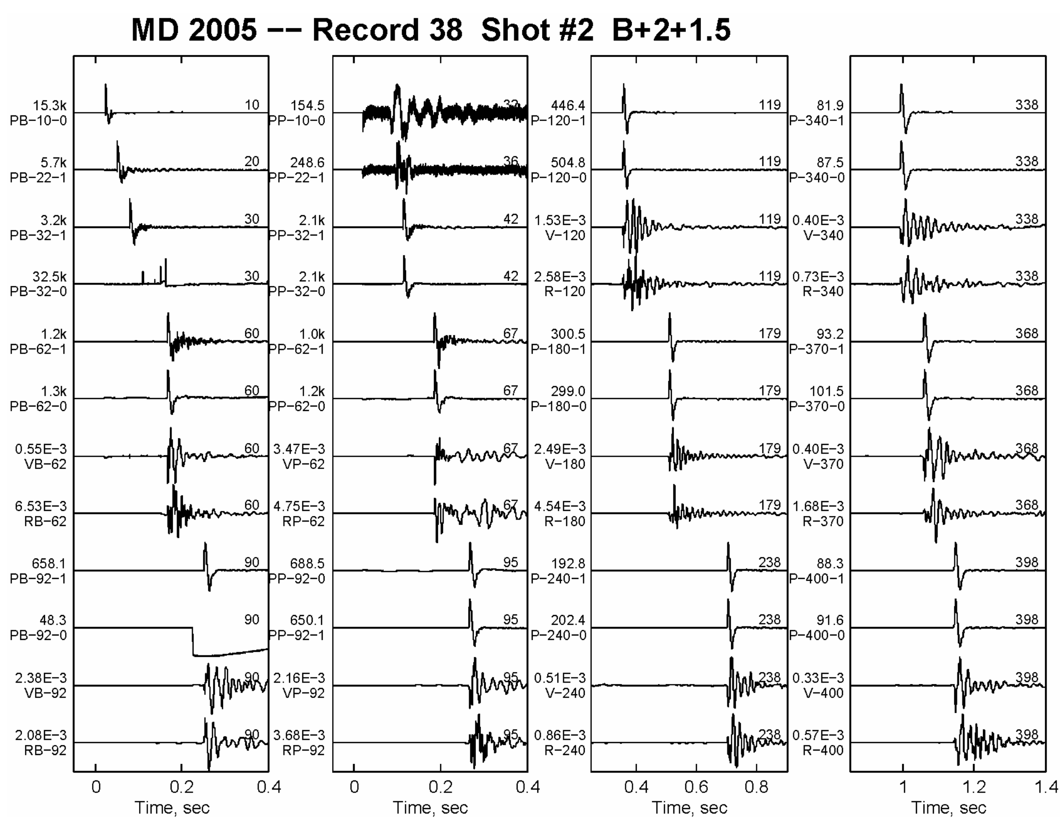


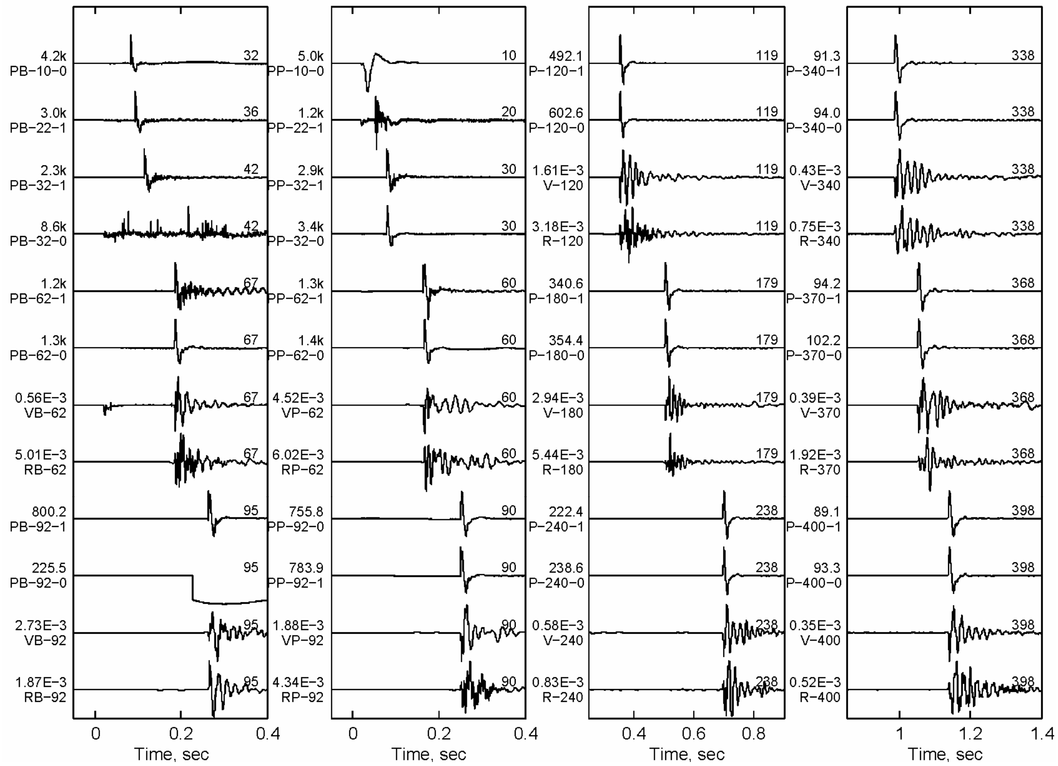
Figure 17. Description of blasting cap data plots.

C-4 data plots

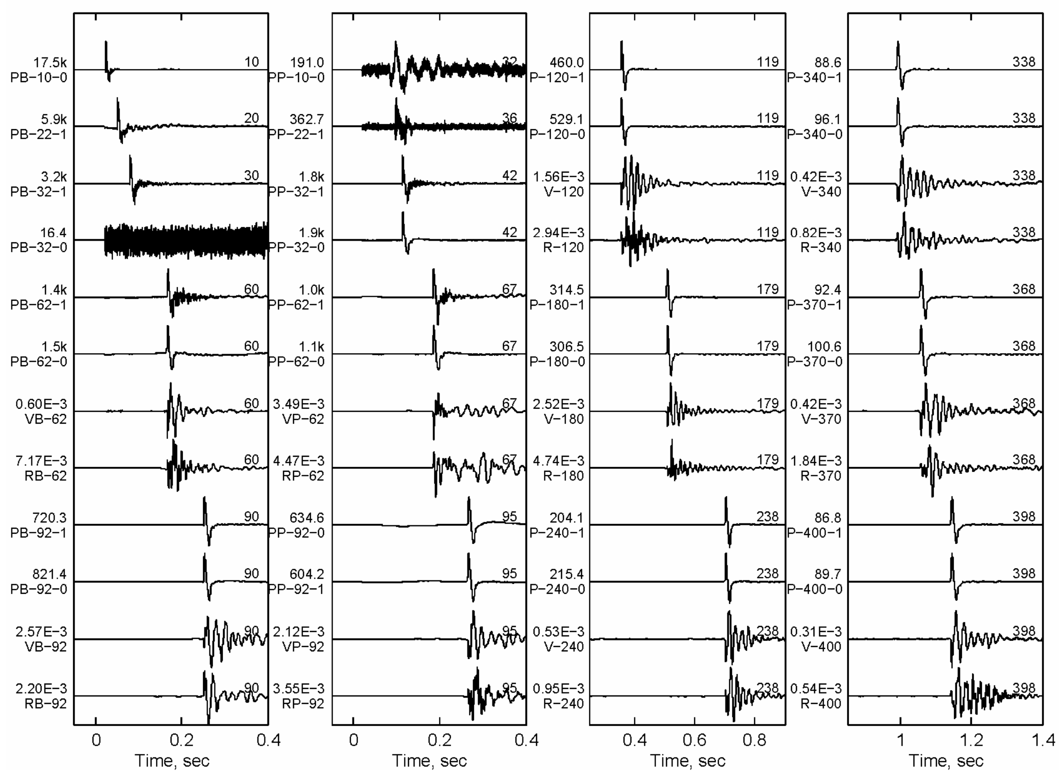




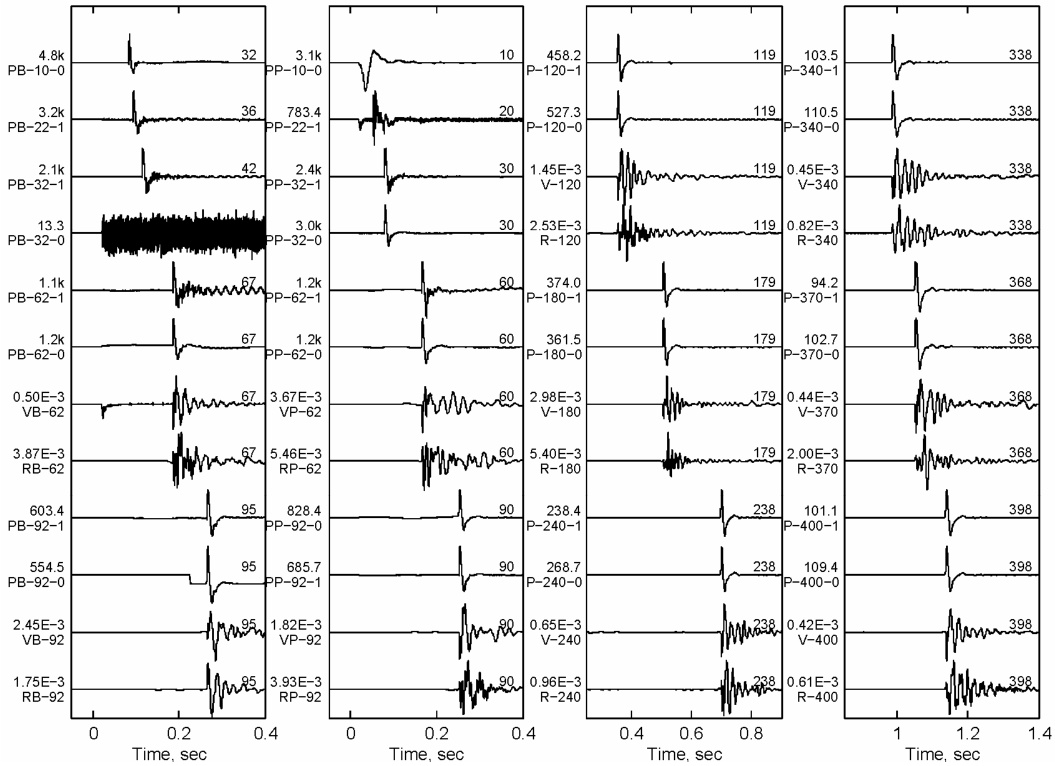
MD 2005 -- Record 39 Shot #3 P+2+1.5



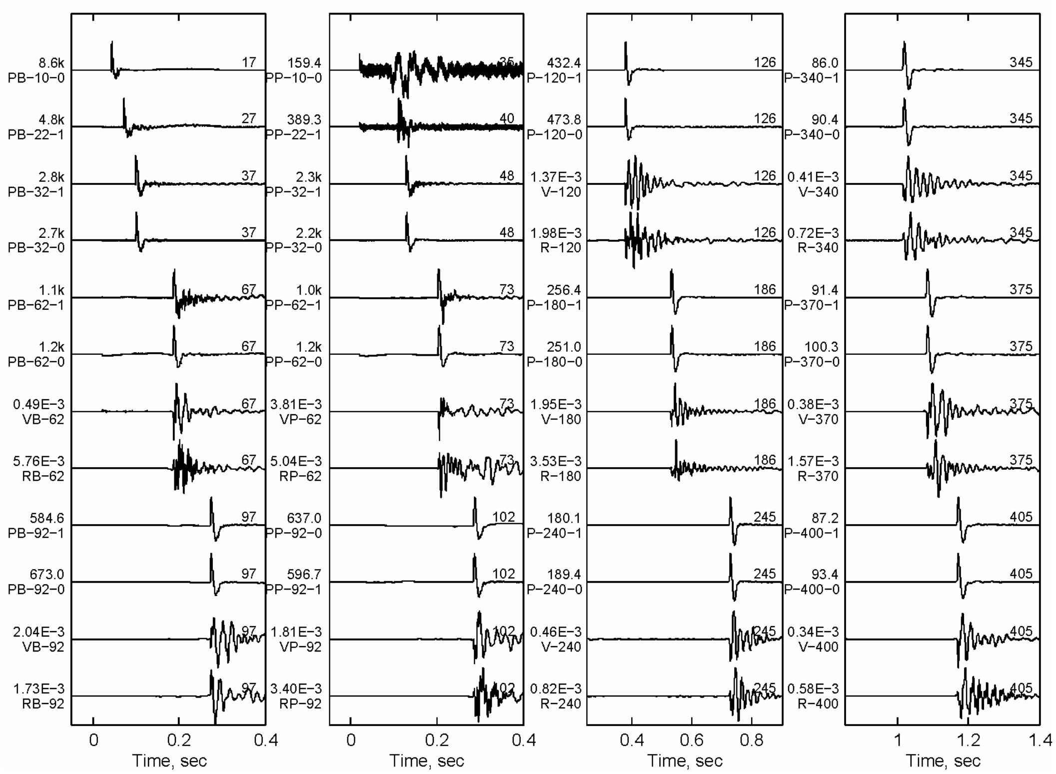
MD 2005 -- Record 40 Shot #4 B+2+1.5

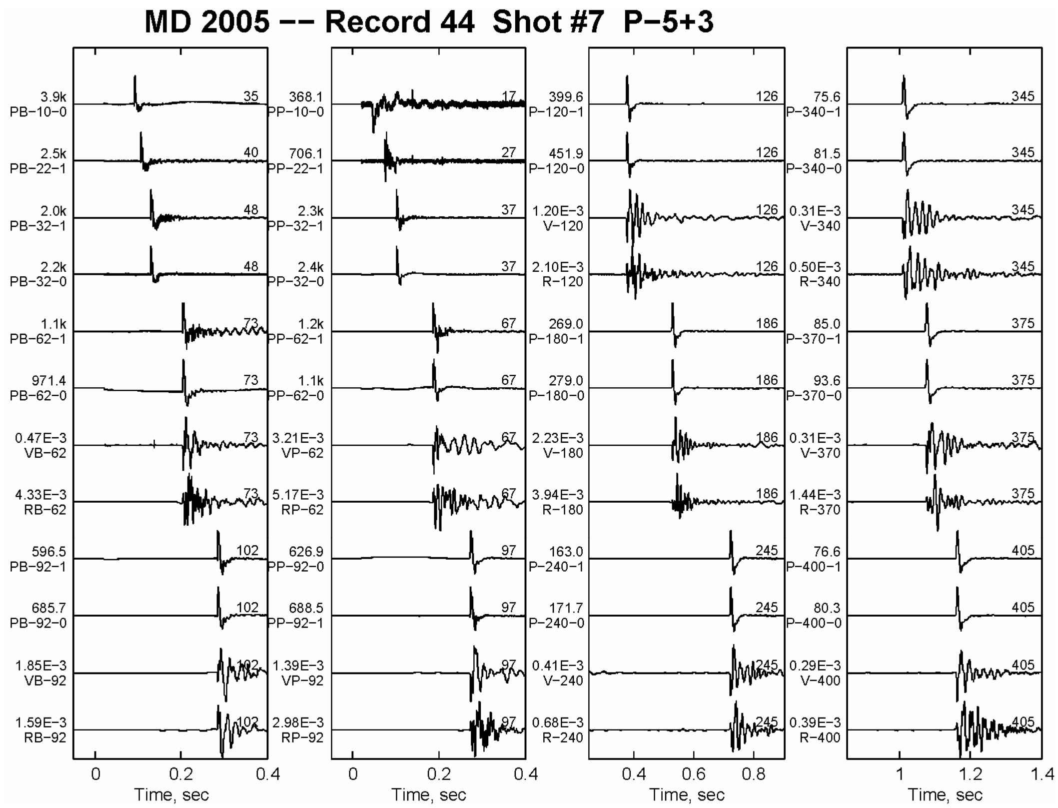


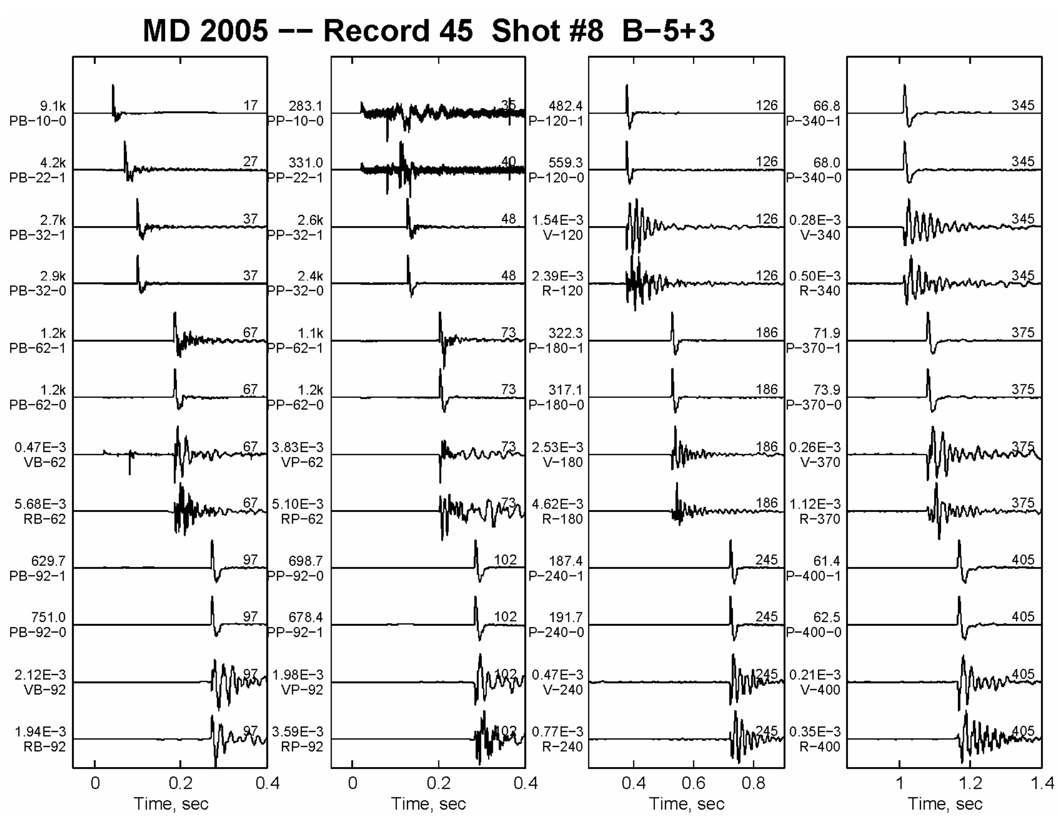
MD 2005 -- Record 42 Shot #5 P+2+1.5



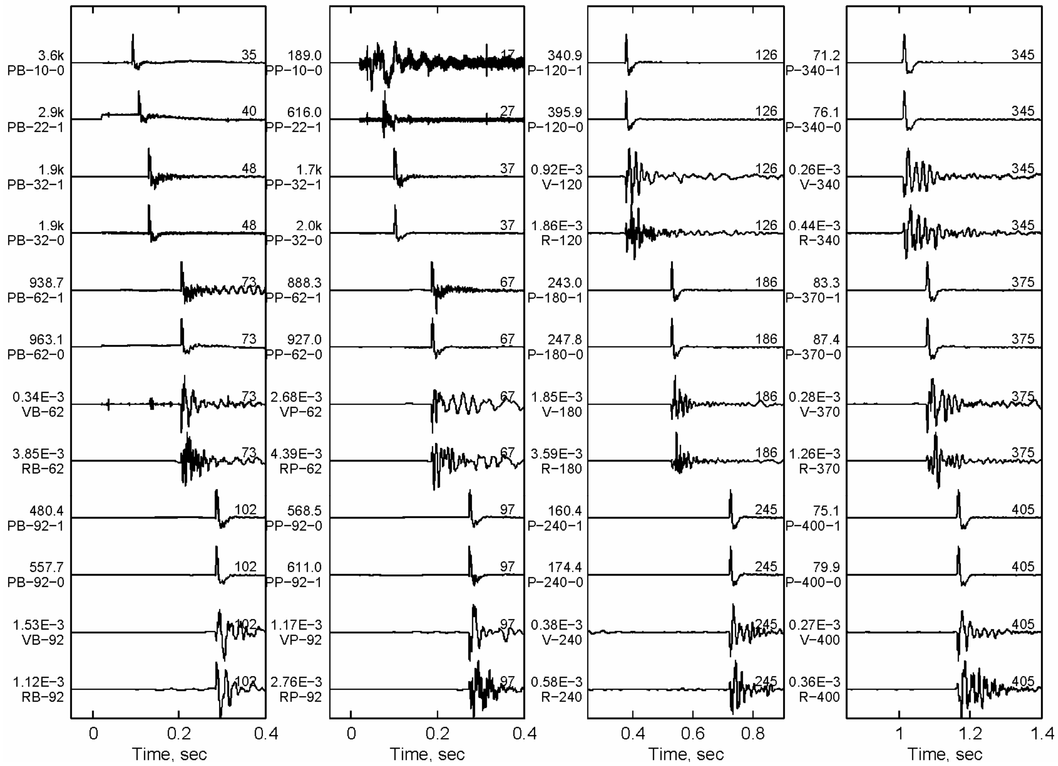
MD 2005 -- Record 43 Shot #6 B−5+3



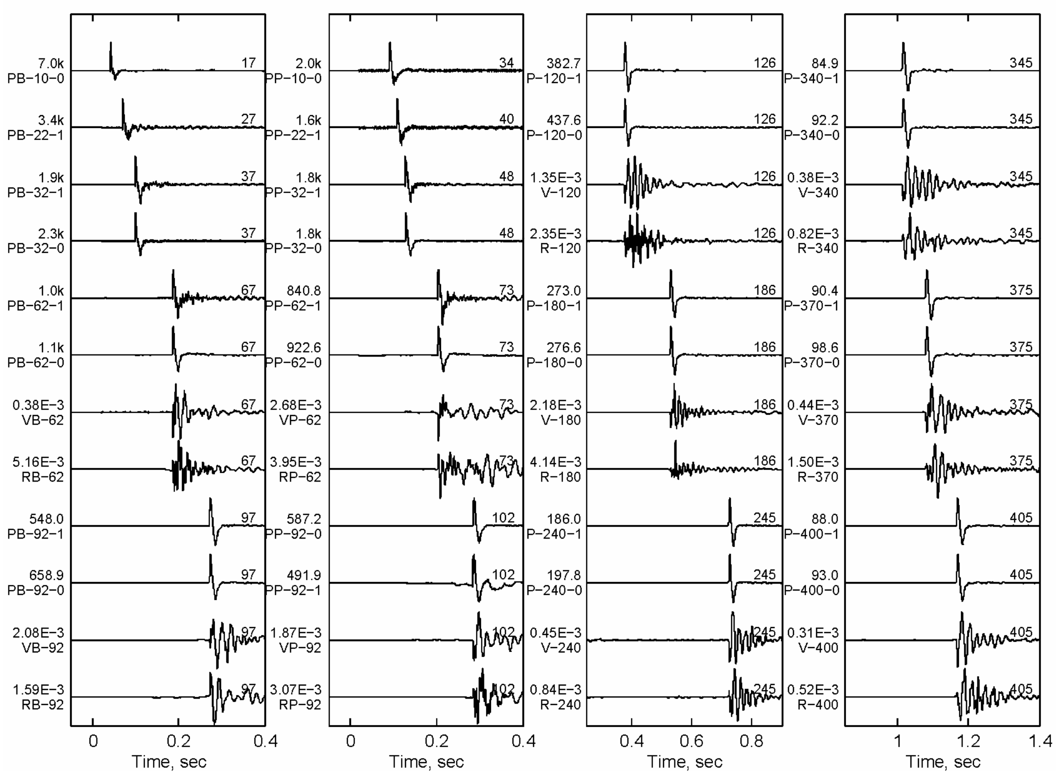

MD 2005 -- Record 44 Shot #7 P−5+3
Time, sec


MD 2005 -- Record 45 Shot #8 B−5+3
Time, sec

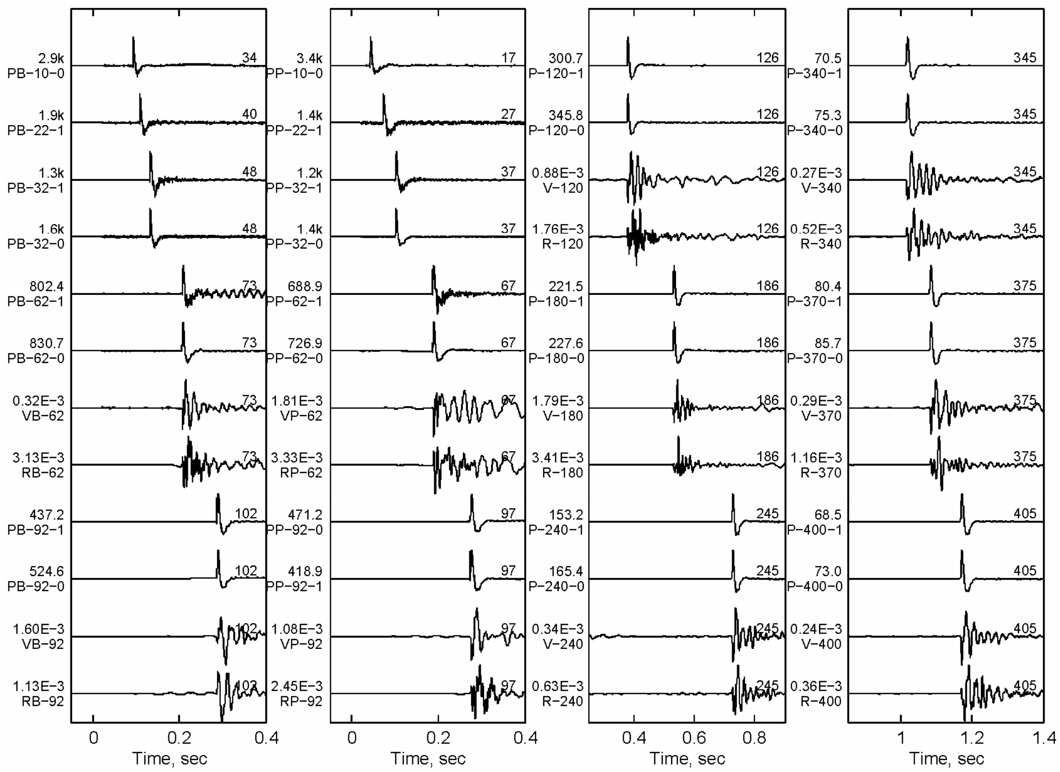
MD 2005 -- Record 46 Shot #9 P-5+3



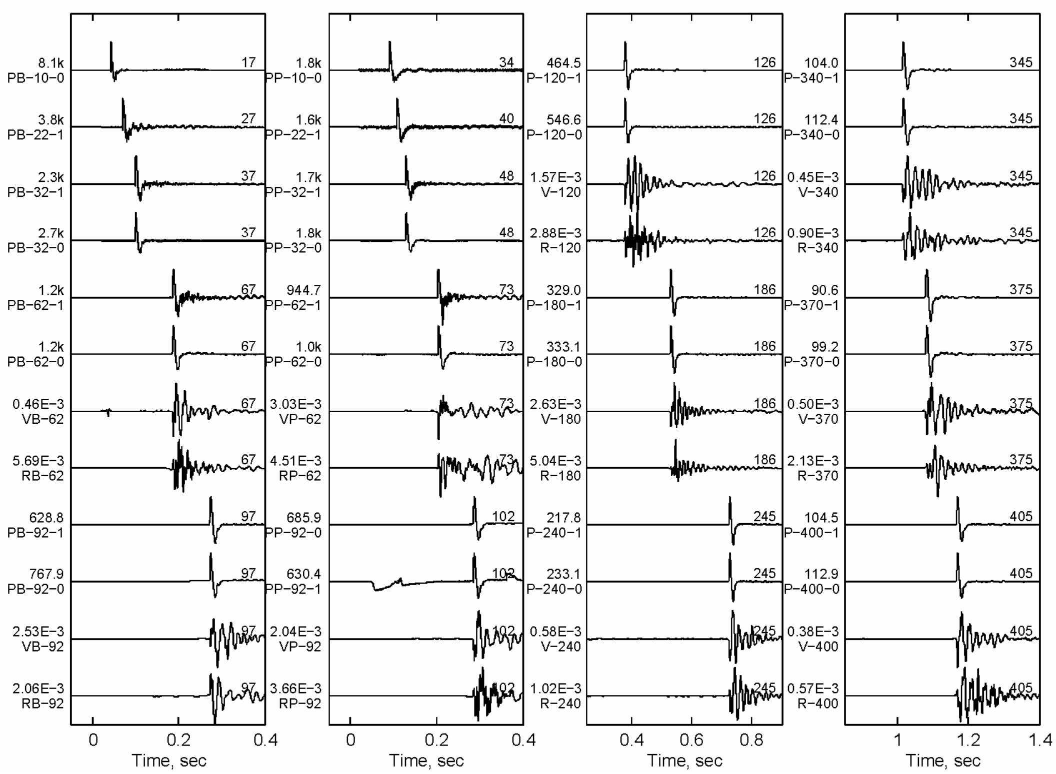
MD 2005 -- Record 69 Shot #10 B-5+1

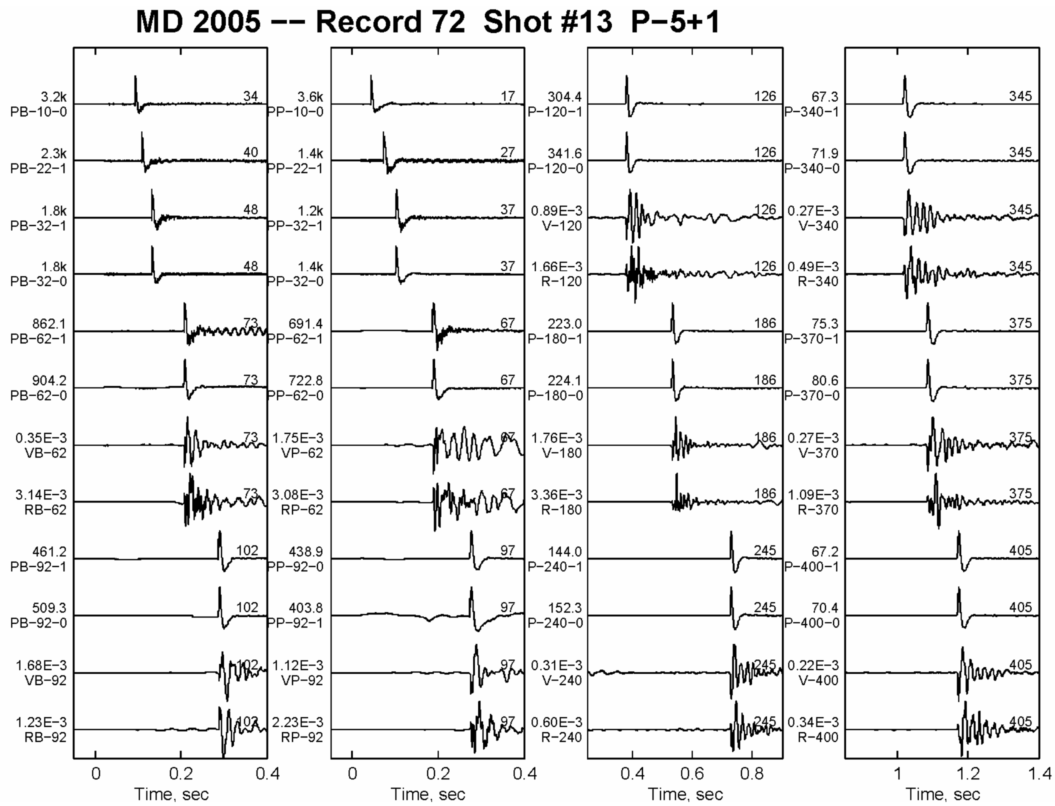


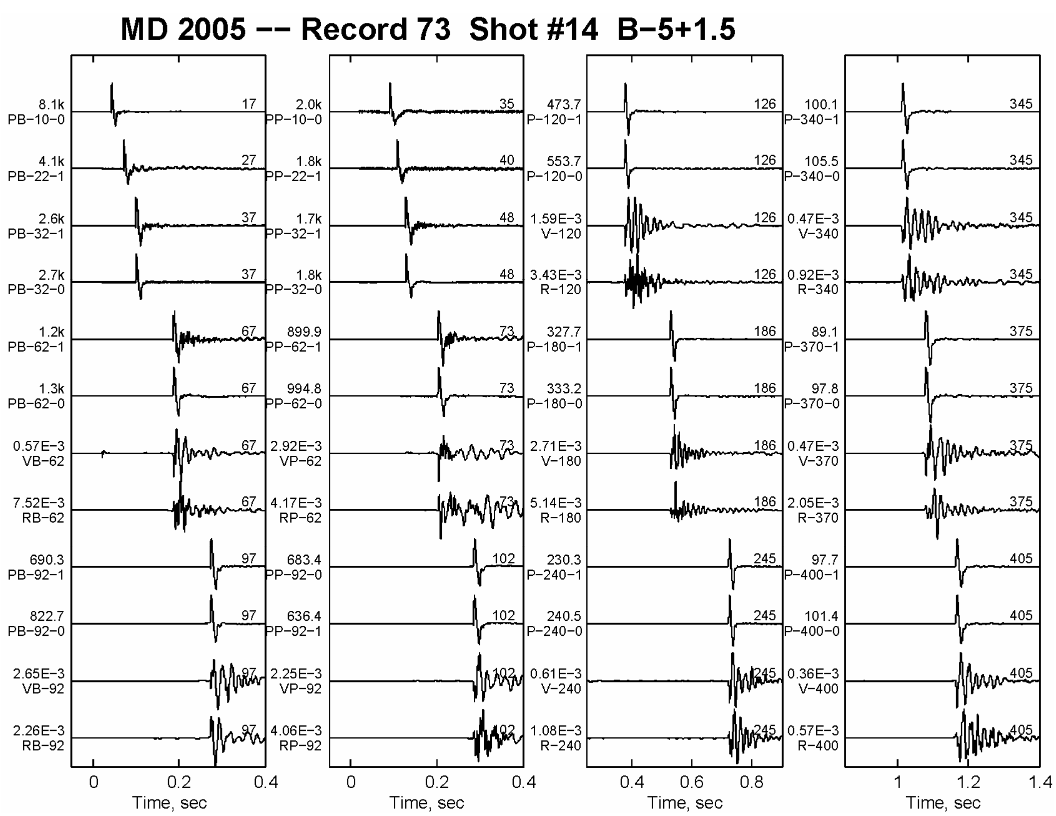
MD 2005 -- Record 70 Shot #11 P−5+1



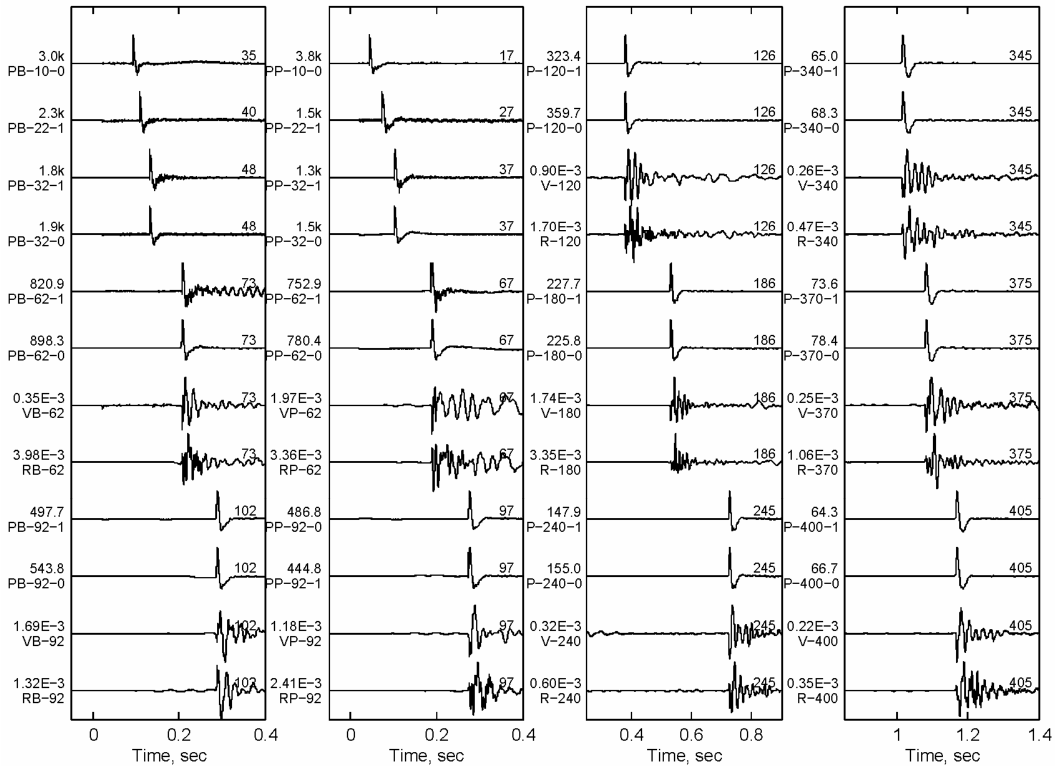
MD 2005 -- Record 71 Shot #12 B−5+1



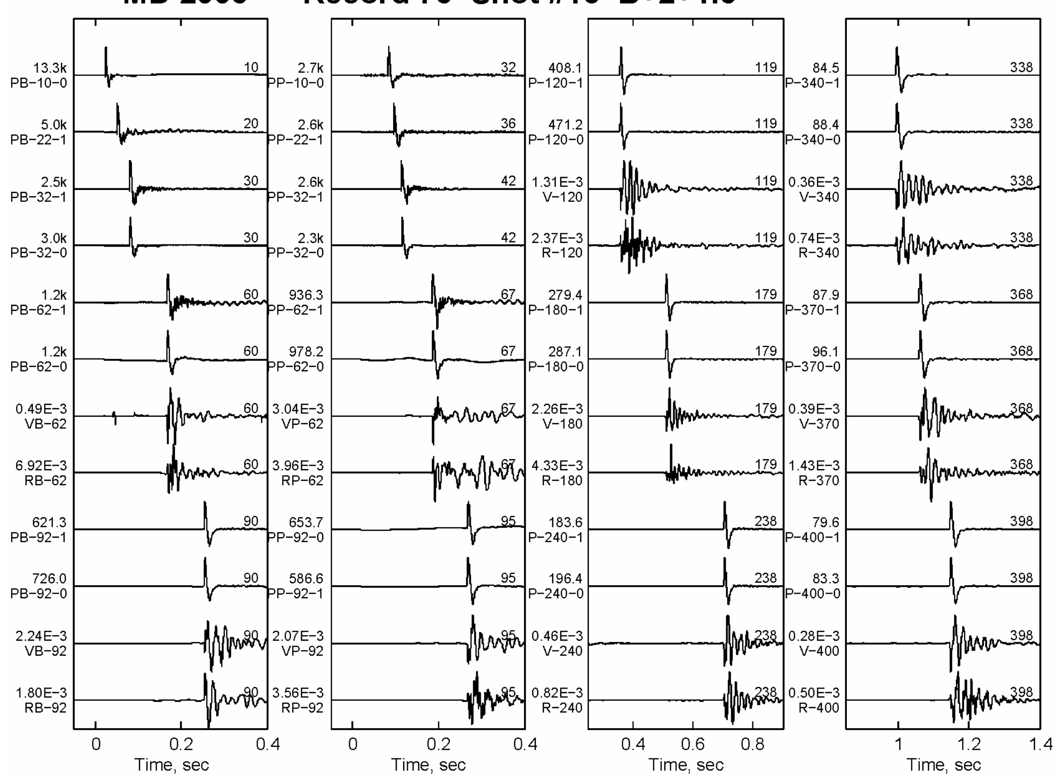

MD 2005 -- Record 72 Shot #13 P-5+1
Time, sec


MD 2005 -- Record 73 Shot #14 B-5+1.5
Time, sec

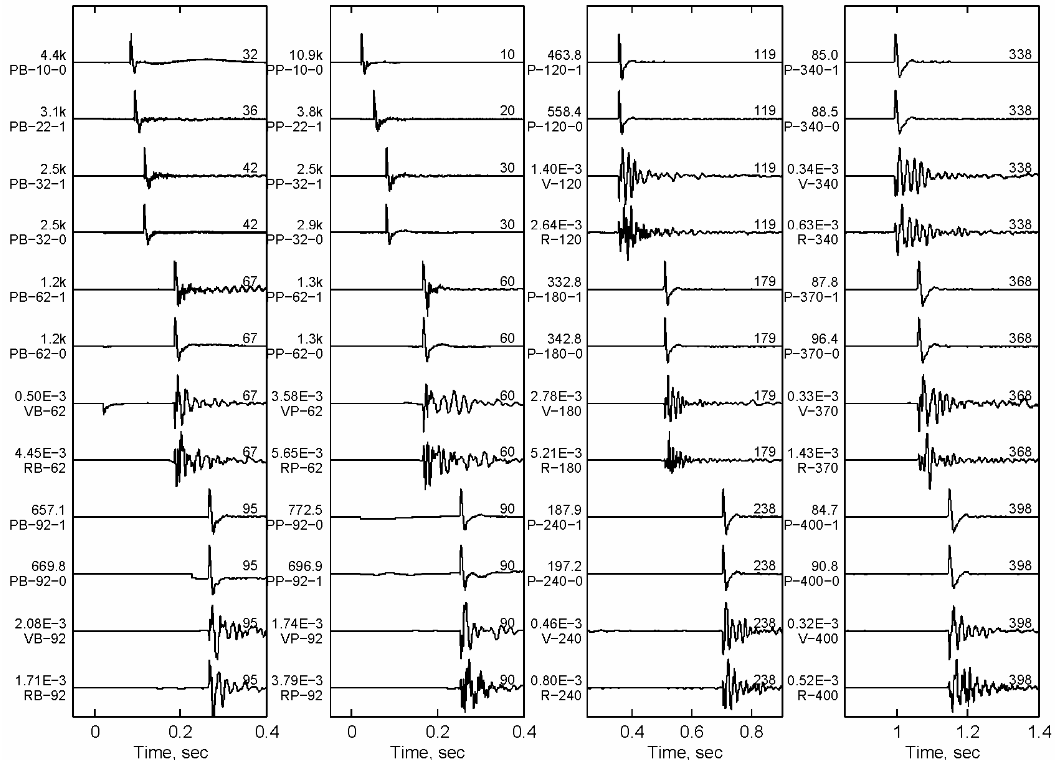
MD 2005 −− Record 74 Shot #15 P−5+1.5



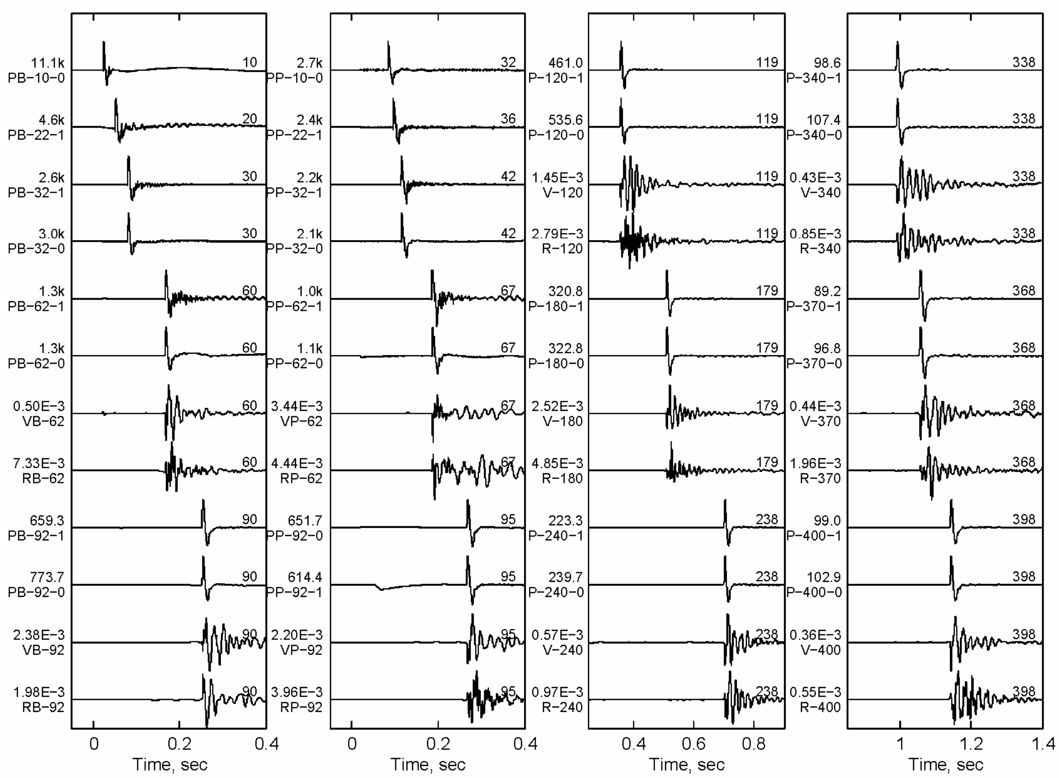
MD 2005 −− Record 75 Shot #16 B+2+1.5



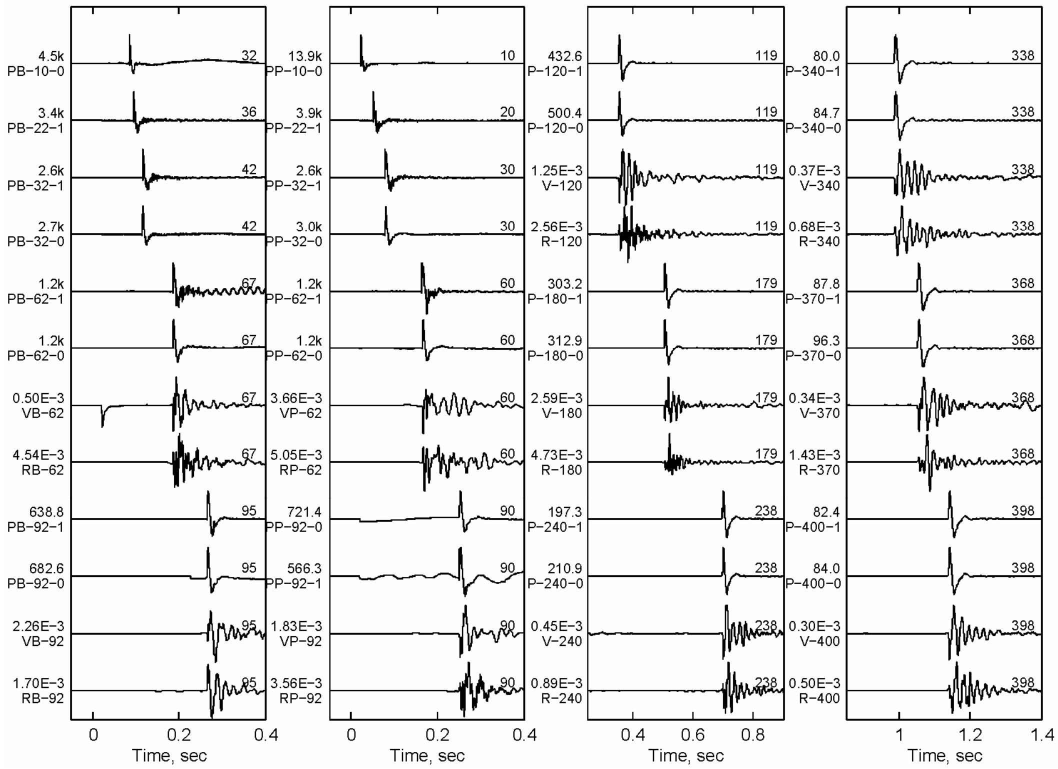
MD 2005 -- Record 76 Shot #17 P+2+1.5



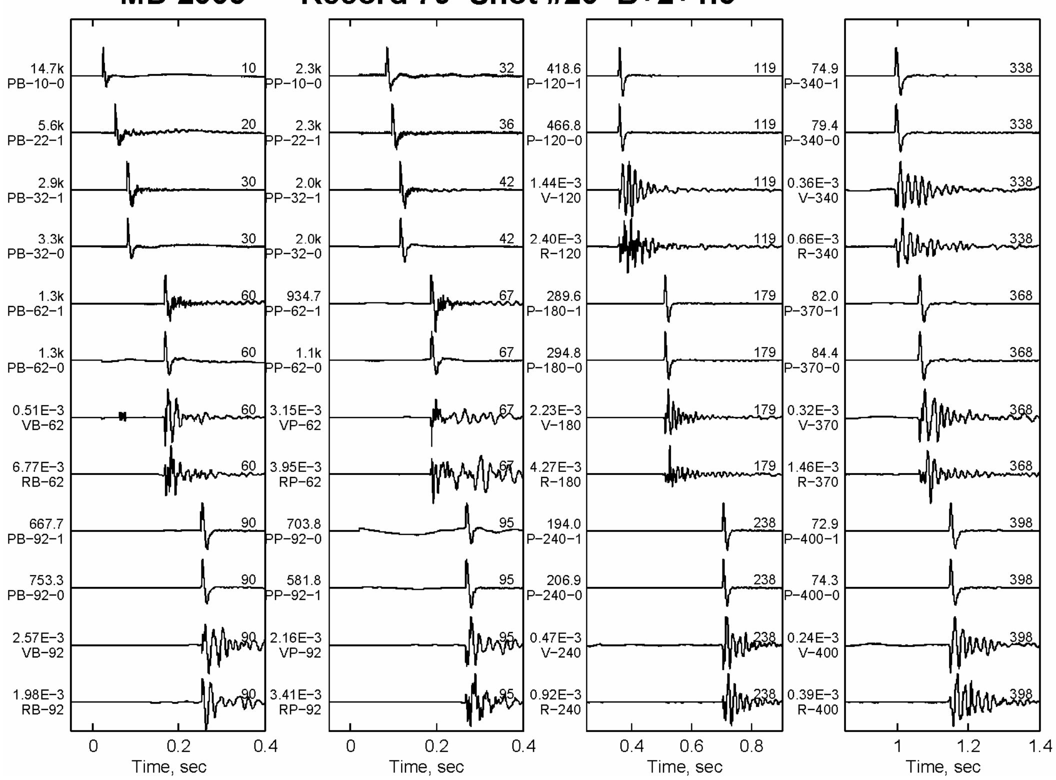
MD 2005 -- Record 77 Shot #18 B+2+1.5



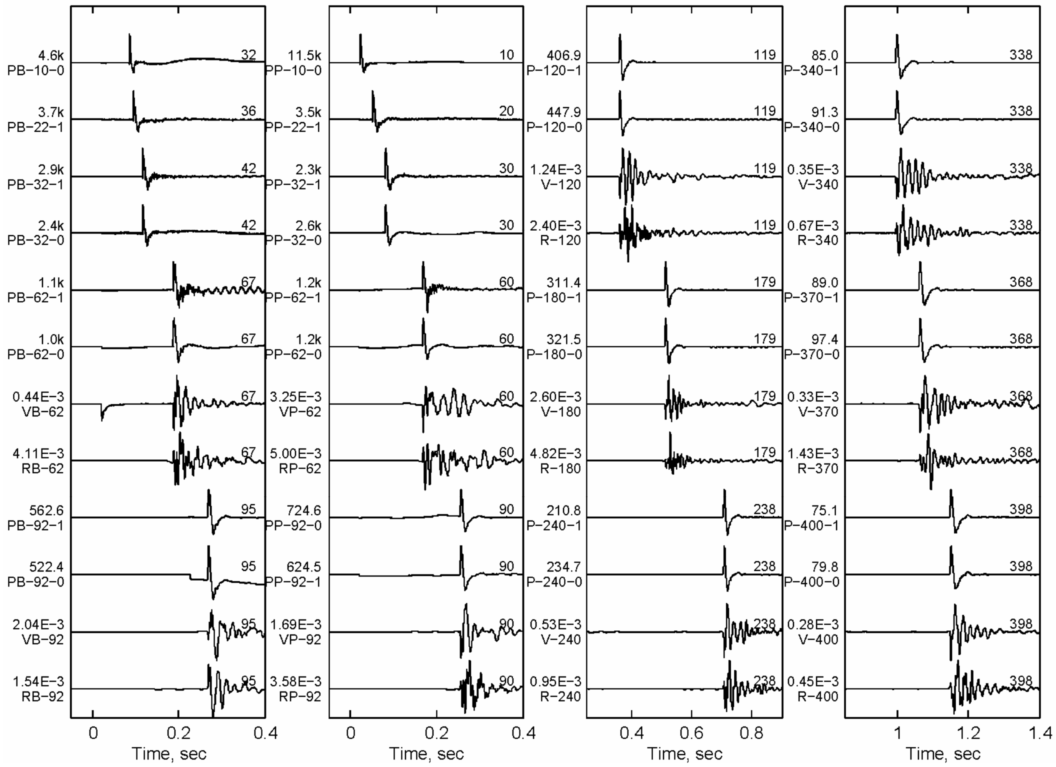
MD 2005 -- Record 78 Shot #19 P+2+1.5



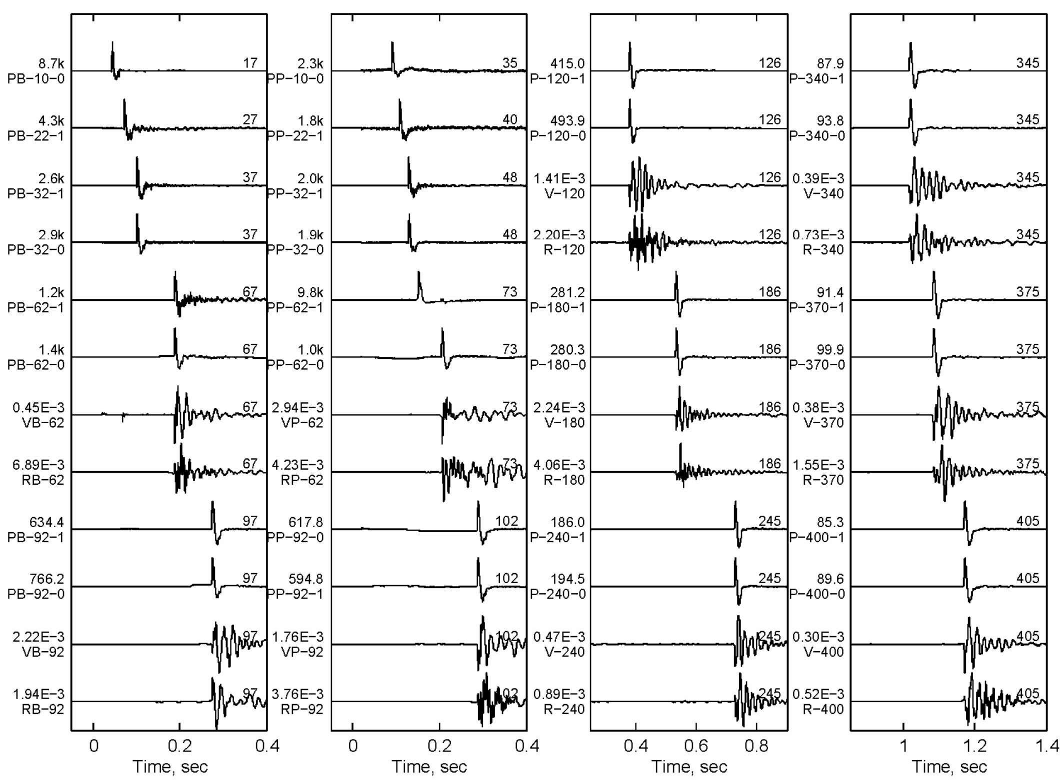
MD 2005 -- Record 79 Shot #20 B+2+1.5

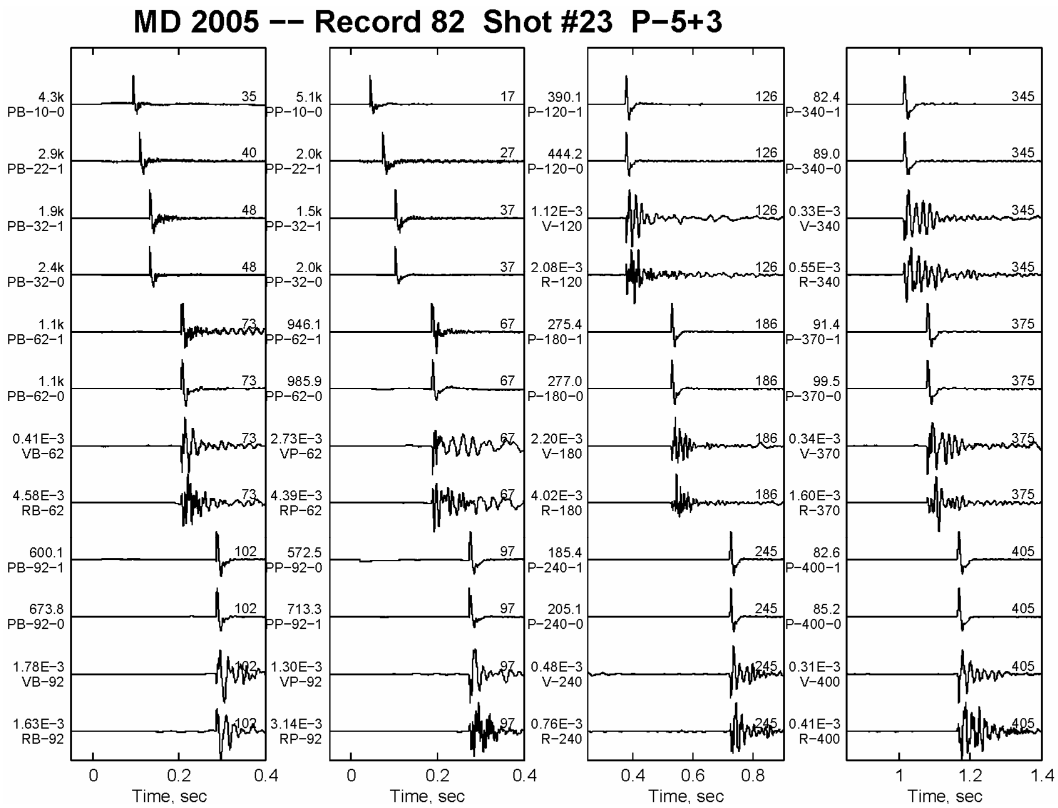


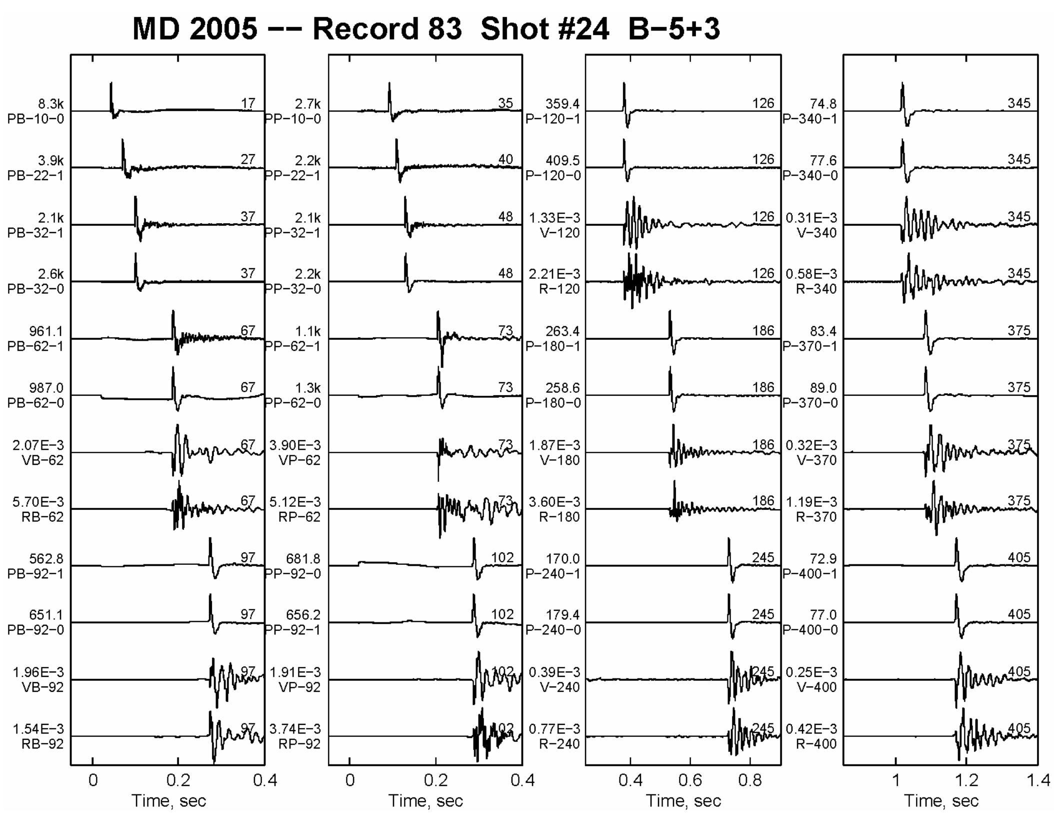
MD 2005 -- Record 80 Shot #21 P+2+1.5



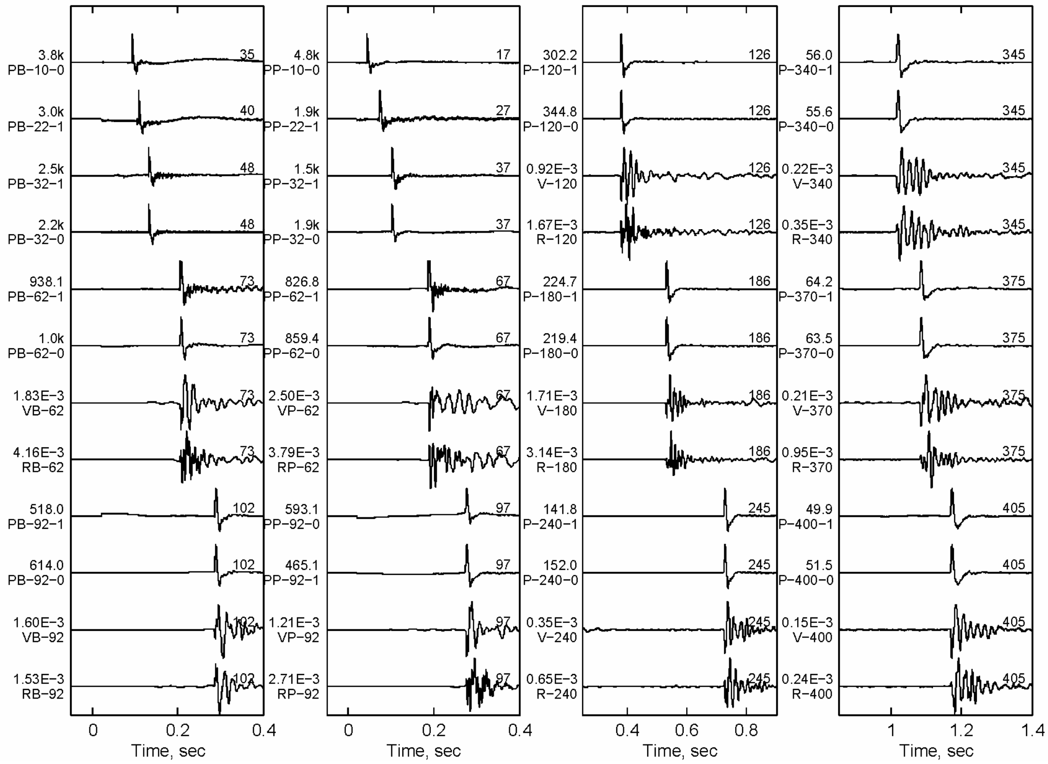
MD 2005 -- Record 81 Shot #22 B−5+3



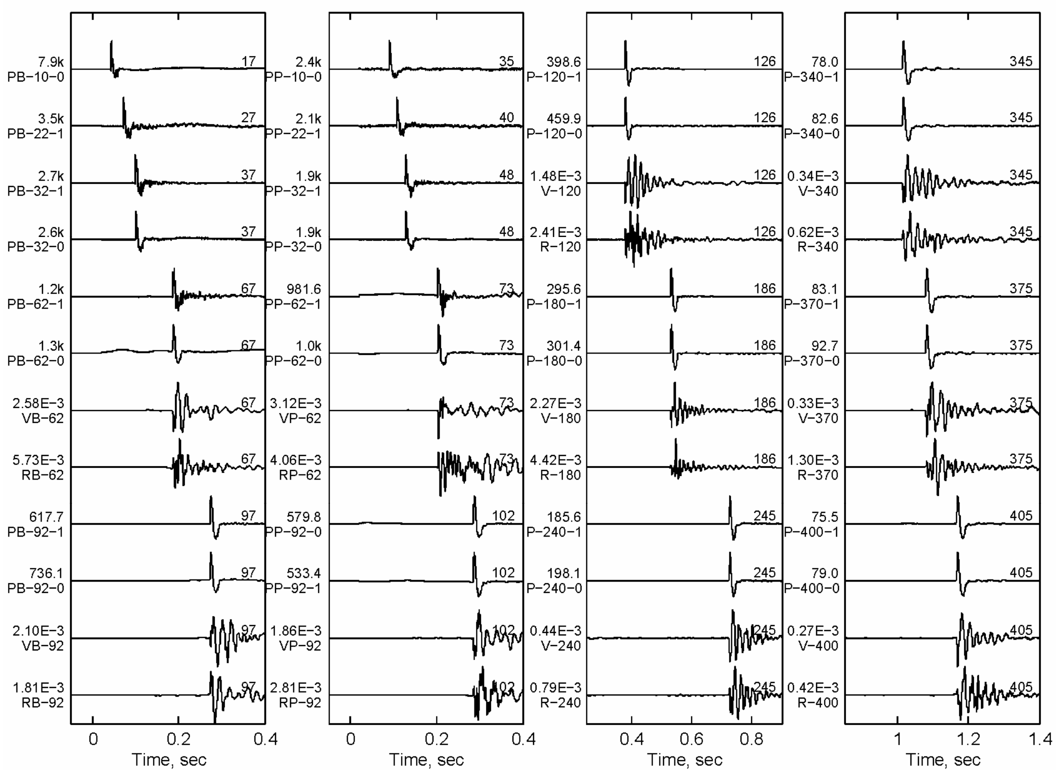

MD 2005 -- Record 82 Shot #23 P-5+3
Time, sec

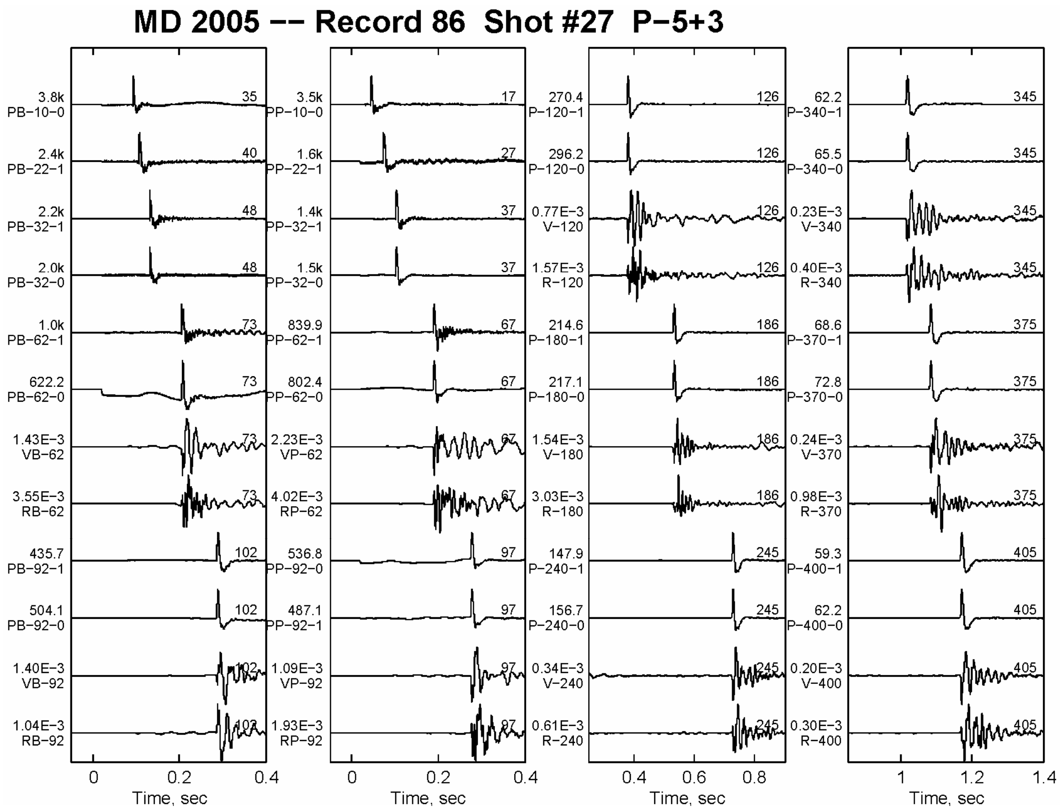

MD 2005 -- Record 83 Shot #24 B-5+3
Time, sec

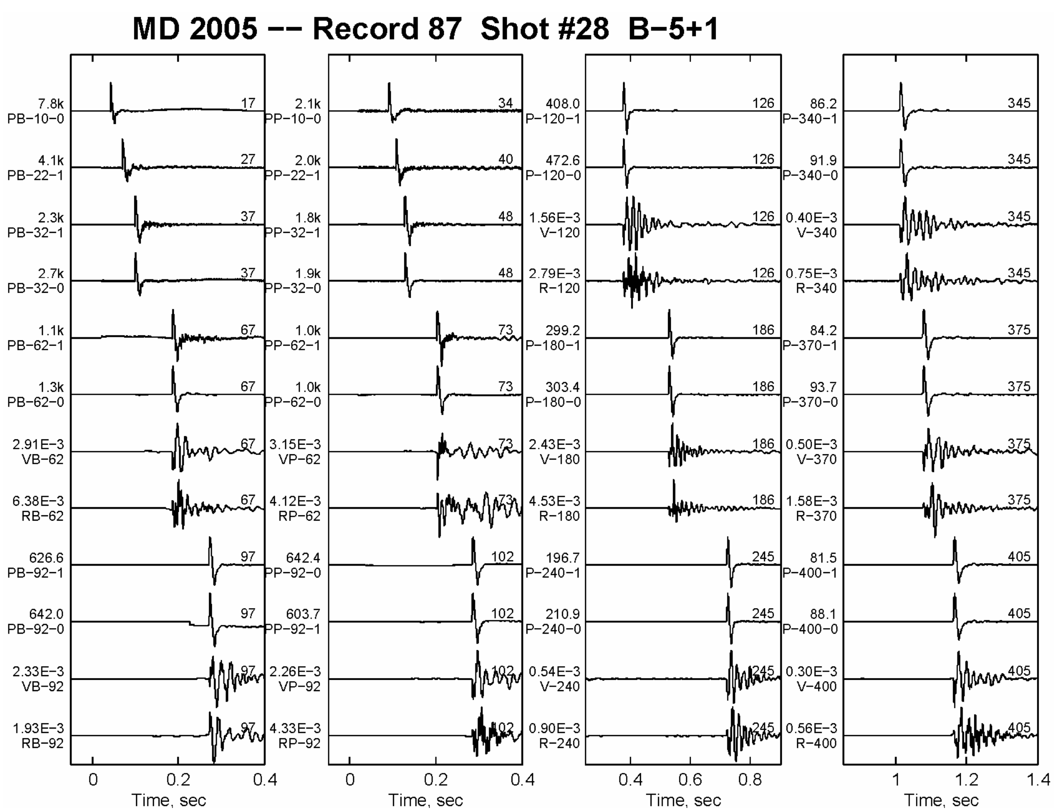
MD 2005 -- Record 84 Shot #25 P-5+3

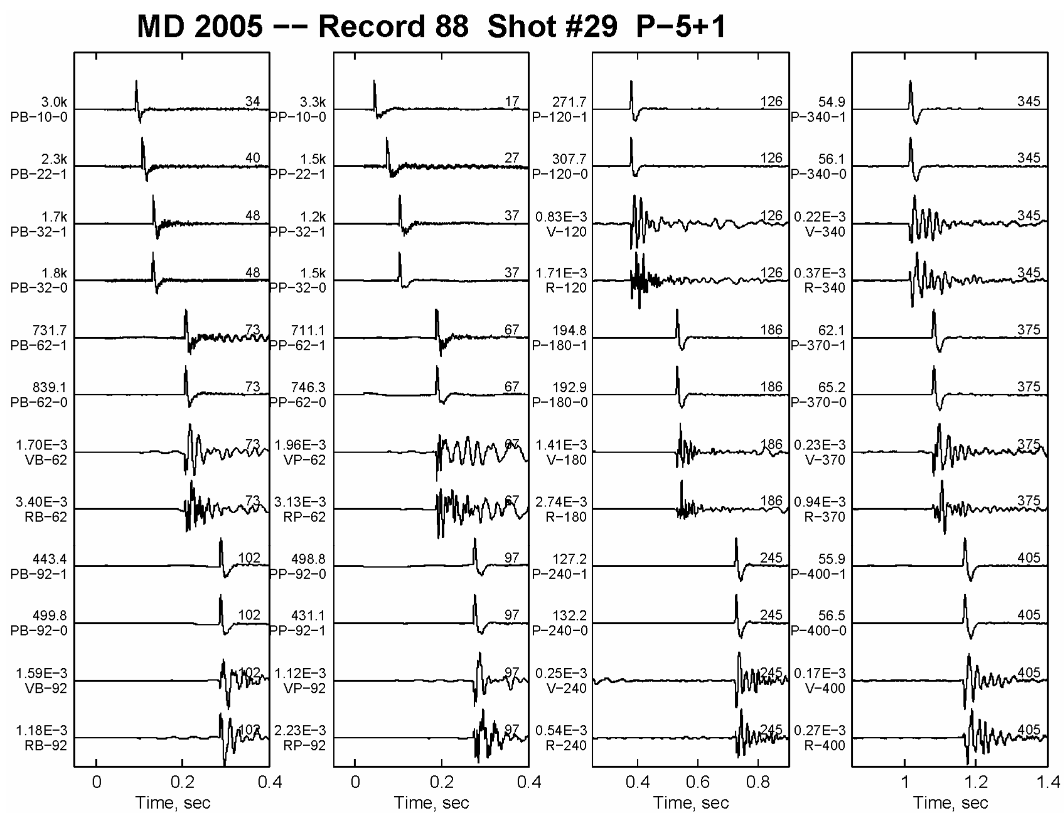


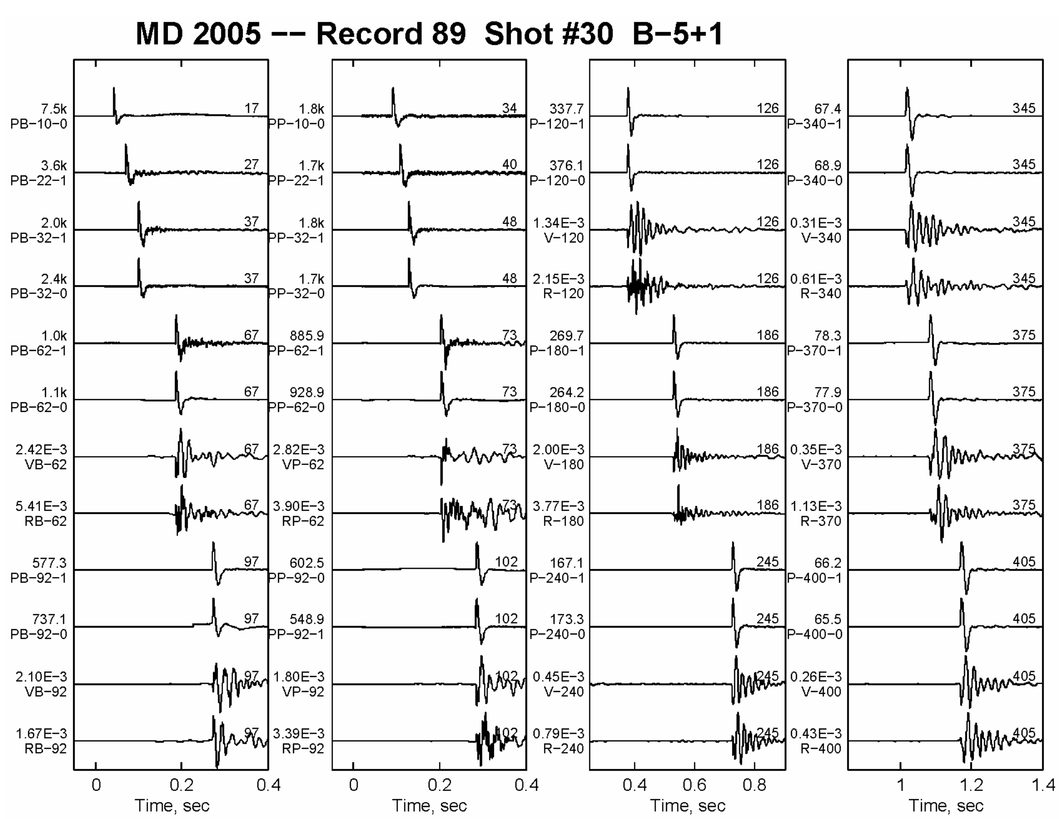
MD 2005 -- Record 85 Shot #26 B-5+3



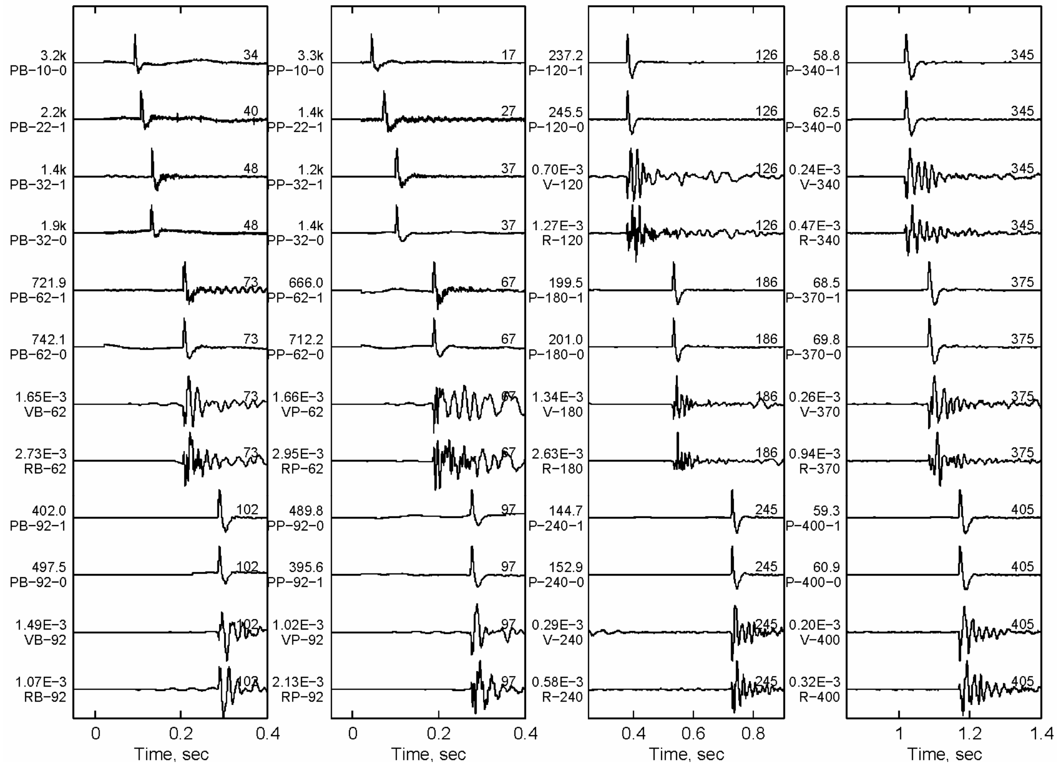

MD 2005 -- Record 86 Shot #27 P-5+3
3.8k PB-10-0 35
2.4k PB-22-1 40
2.2k PB-32-1 48
2.0k PB-32-0 48
1.0k PB-62-1 73
622.2 PB-62-0 73
1.43E-3 VB-62 73
3.55E-3 RB-62 73
435.7 PB-92-1 102
504.1 PB-92-0 102
1.40E-3 VB-92 102
1.04E-3 RB-92 102
3.5k PP-10-0 17
1.6k PP-22-1 27
1.4k PP-32-1 37
1.5k PP-32-0 37
839.9 PP-62-1 67
802.4 PP-62-0 67
2.23E-3 VP-62 67
4.02E-3 RP-62 67
536.8 PP-92-0 97
487.1 PP-92-1 97
1.09E-3 VP-92 97
1.93E-3 RP-92 97
270.4 P-120-1 126
296.2 P-120-0 126
0.77E-3 V-120 126
1.57E-3 R-120 126
214.6 P-180-1 186
217.1 P-180-0 186
1.54E-3 V-180 186
3.03E-3 R-180 186
147.9 P-240-1 245
156.7 P-240-0 245
0.34E-3 V-240 245
0.61E-3 R-240 245
62.2 P-340-1 345
65.5 P-340-0 345
0.23E-3 V-340 345
0.40E-3 R-340 345
68.6 P-370-1 375
72.8 P-370-0 375
0.24E-3 V-370 375
0.98E-3 R-370 375
59.3 P-400-1 405
62.2 P-400-0 405
0.20E-3 V-400 405
0.30E-3 R-400 405
0 0.2 0.4
Time, sec
0 0.2 0.4
Time, sec
0.4 0.6 0.8
Time, sec
1 1.2 1.4
Time, sec


MD 2005 -- Record 87 Shot #28 B-5+1
7.8k PB-10-0 17
4.1k PB-22-1 27
2.3k PB-32-1 37
2.7k PB-32-0 37
1.1k PB-62-1 67
1.3k PB-62-0 67
2.91E-3 VB-62 67
6.38E-3 RB-62 67
626.6 PB-92-1 97
642.0 PB-92-0 97
2.33E-3 VB-92 97
1.93E-3 RB-92 97
2.1k PP-10-0 34
2.0k PP-22-1 40
1.8k PP-32-1 48
1.9k PP-32-0 48
1.0k PP-62-1 73
1.0k PP-62-0 73
3.15E-3 VP-62 73
4.12E-3 RP-62 73
642.4 PP-92-0 102
603.7 PP-92-1 102
2.26E-3 VP-92 102
4.33E-3 RP-92 102
408.0 P-120-1 126
472.6 P-120-0 126
1.56E-3 V-120 126
2.79E-3 R-120 126
299.2 P-180-1 186
303.4 P-180-0 186
2.43E-3 V-180 186
4.53E-3 R-180 186
196.7 P-240-1 245
210.9 P-240-0 245
0.54E-3 V-240 245
0.90E-3 R-240 245
86.2 P-340-1 345
91.9 P-340-0 345
0.40E-3 V-340 345
0.75E-3 R-340 345
84.2 P-370-1 375
93.7 P-370-0 375
0.50E-3 V-370 375
1.58E-3 R-370 375
81.5 P-400-1 405
88.1 P-400-0 405
0.30E-3 V-400 405
0.56E-3 R-400 405
0 0.2 0.4
Time, sec
0 0.2 0.4
Time, sec
0.4 0.6 0.8
Time, sec
1 1.2 1.4
Time, sec

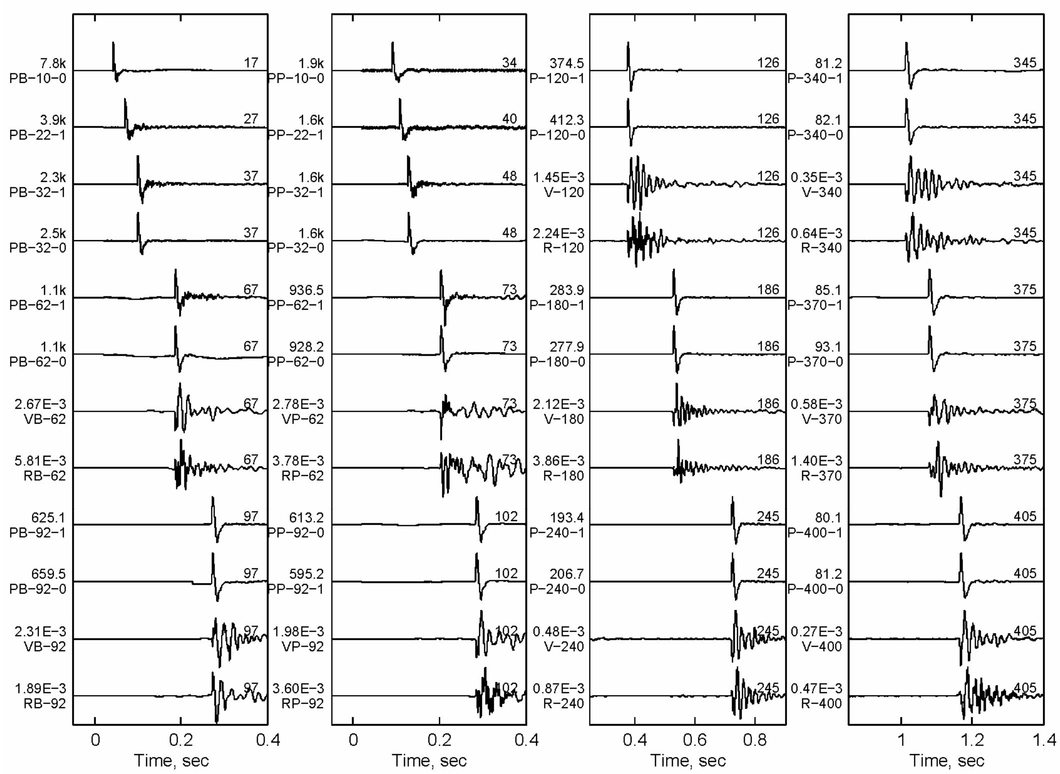


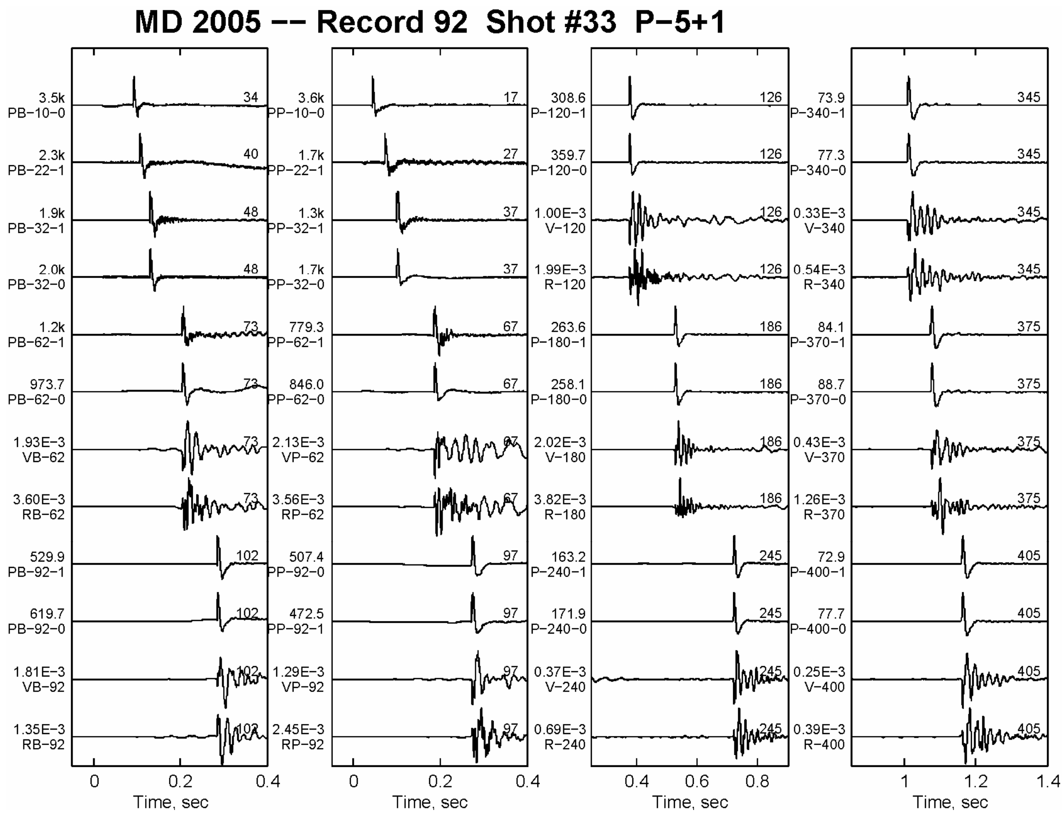


MD 2005 -- Record 90 Shot #31 P-5+1

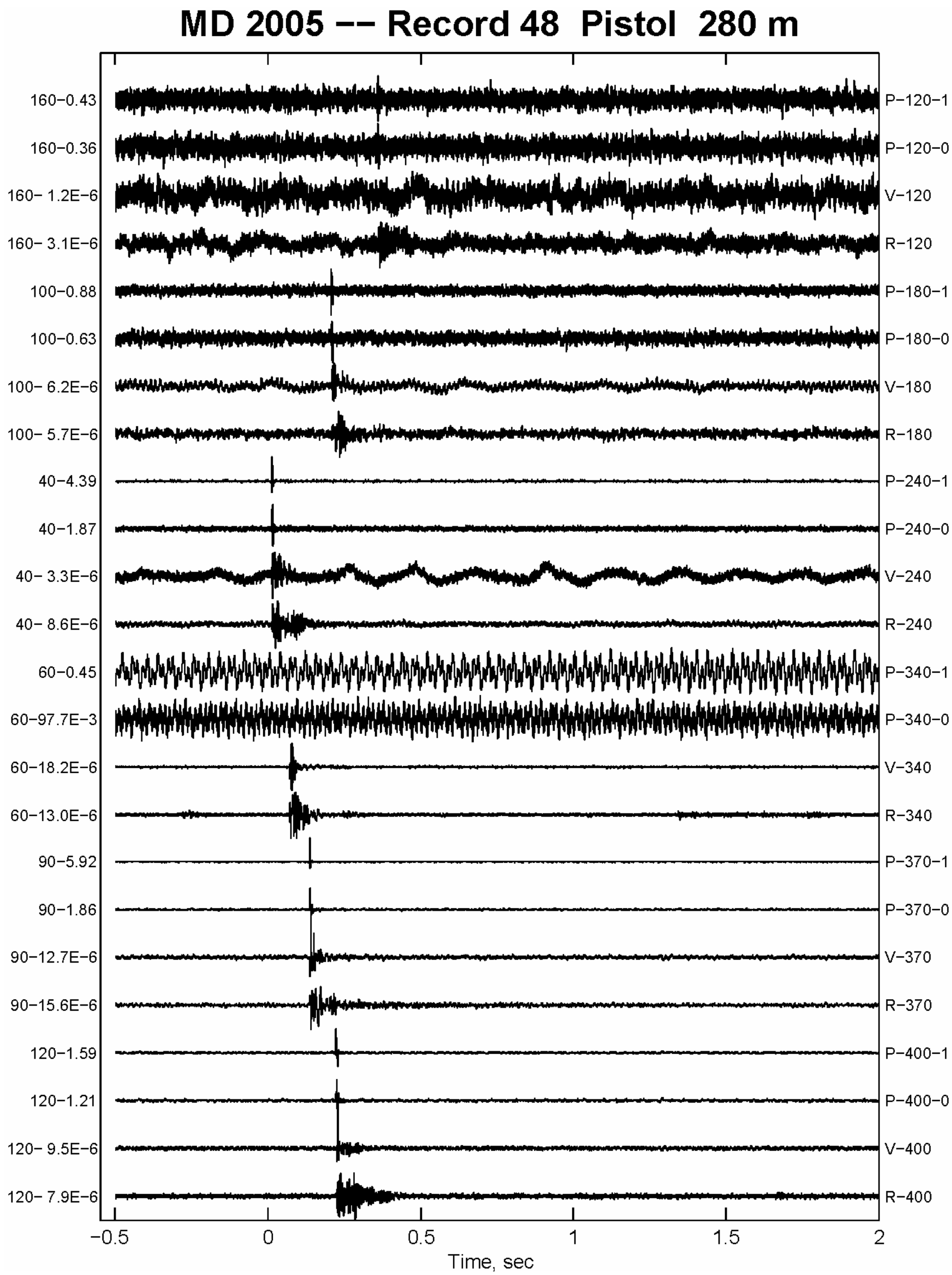


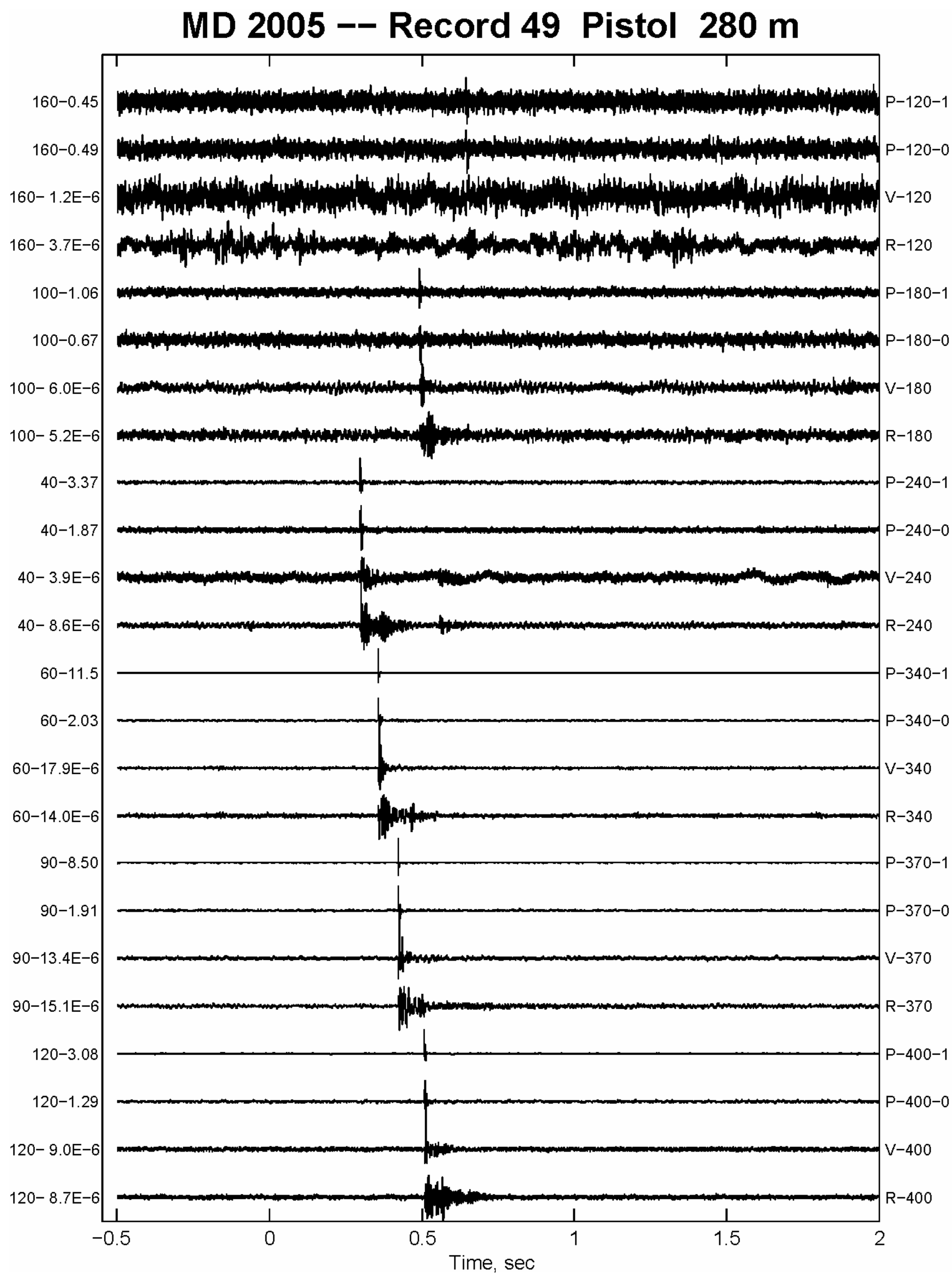
MD 2005 -- Record 91 Shot #32 B-5+1

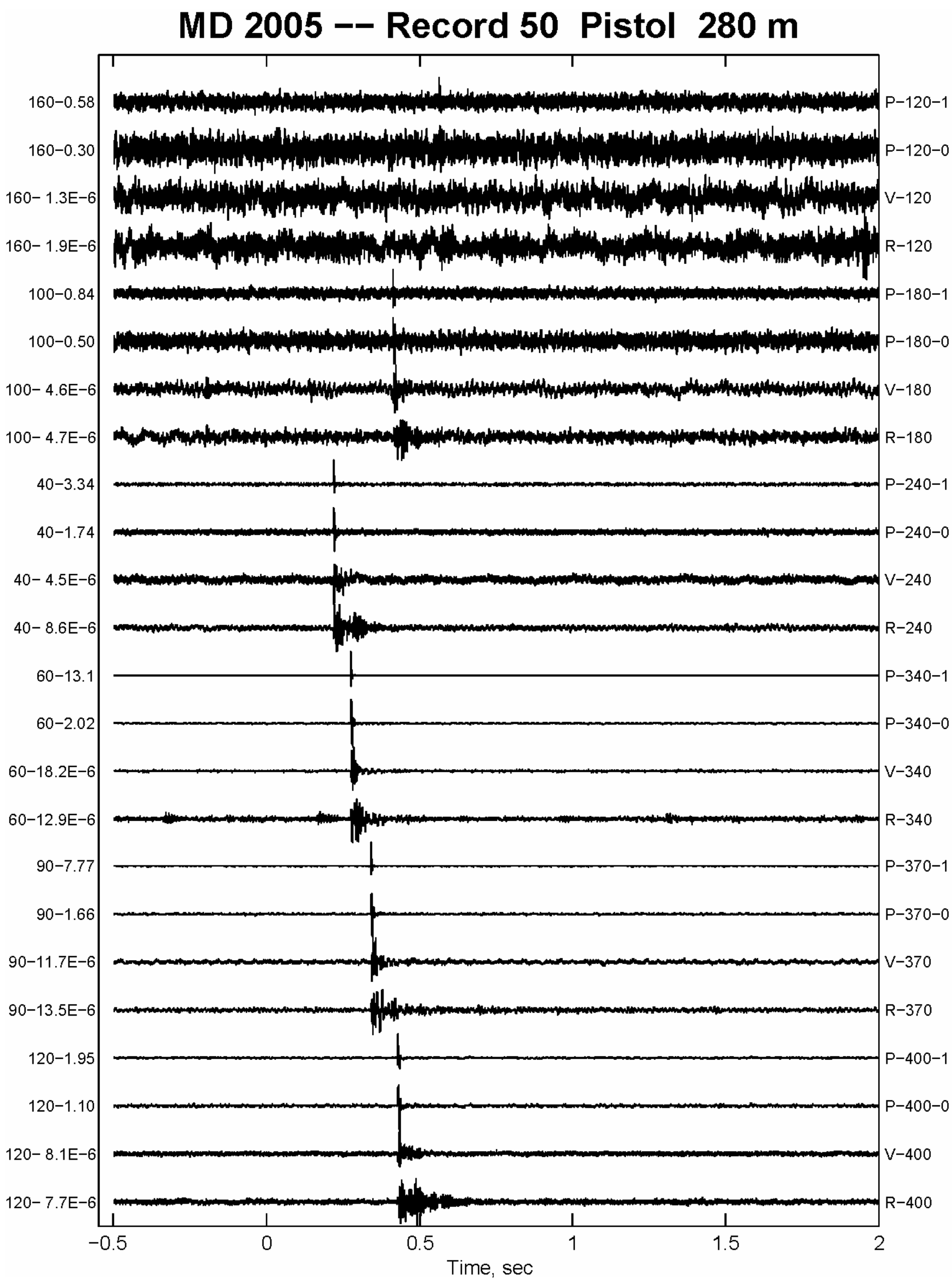


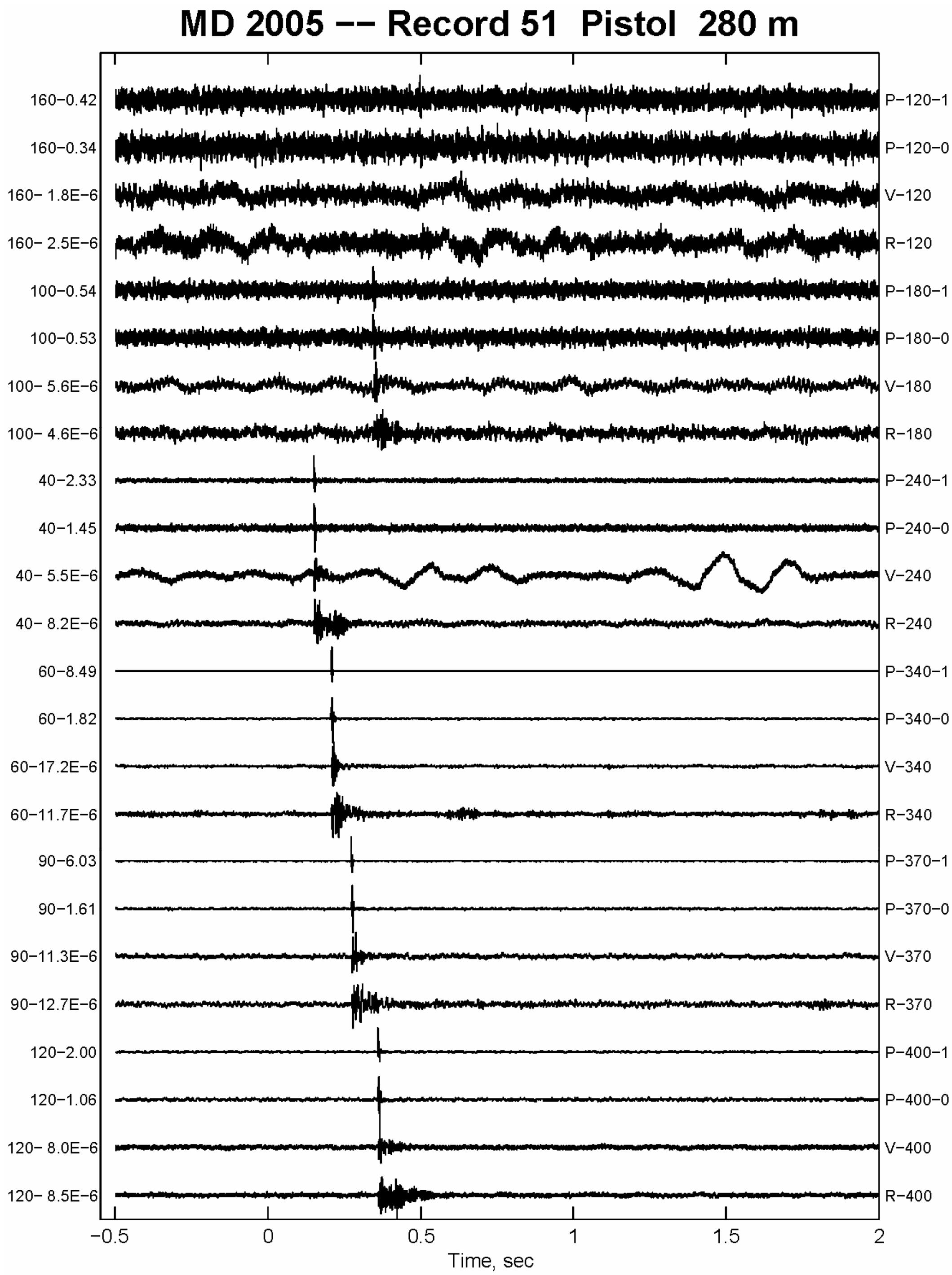

MD 2005 -- Record 92 Shot #33 P-5+1
3.5k PB-10-0 34
2.3k PB-22-1 40
1.9k PB-32-1 48
2.0k PB-32-0 48
1.2k PB-62-1 73
973.7 PB-62-0 73
1.93E-3 VB-62 73
3.60E-3 RB-62 73
529.9 PB-92-1 102
619.7 PB-92-0 102
1.81E-3 VB-92 102
1.35E-3 RB-92 102
3.6k PP-10-0 17
1.7k PP-22-1 27
1.3k PP-32-1 37
1.7k PP-32-0 37
779.3 PP-62-1 67
846.0 PP-62-0 67
2.13E-3 VP-62 67
3.56E-3 RP-62 67
507.4 PP-92-0 97
472.5 PP-92-1 97
1.29E-3 VP-92 97
2.45E-3 RP-92 97
308.6 P-120-1 126
359.7 P-120-0 126
1.00E-3 V-120 126
1.99E-3 R-120 126
263.6 P-180-1 186
258.1 P-180-0 186
2.02E-3 V-180 186
3.82E-3 R-180 186
163.2 P-240-1 245
171.9 P-240-0 245
0.37E-3 V-240 245
0.69E-3 R-240 245
73.9 P-340-1 345
77.3 P-340-0 345
0.33E-3 V-340 345
0.54E-3 R-340 345
84.1 P-370-1 375
88.7 P-370-0 375
0.43E-3 V-370 375
1.26E-3 R-370 375
72.9 P-400-1 405
77.7 P-400-0 405
0.25E-3 V-400 405
0.39E-3 R-400 405
0 0.2 0.4
0 0.2 0.4
0.4 0.6 0.8
1 1.2 1.4
Time, sec

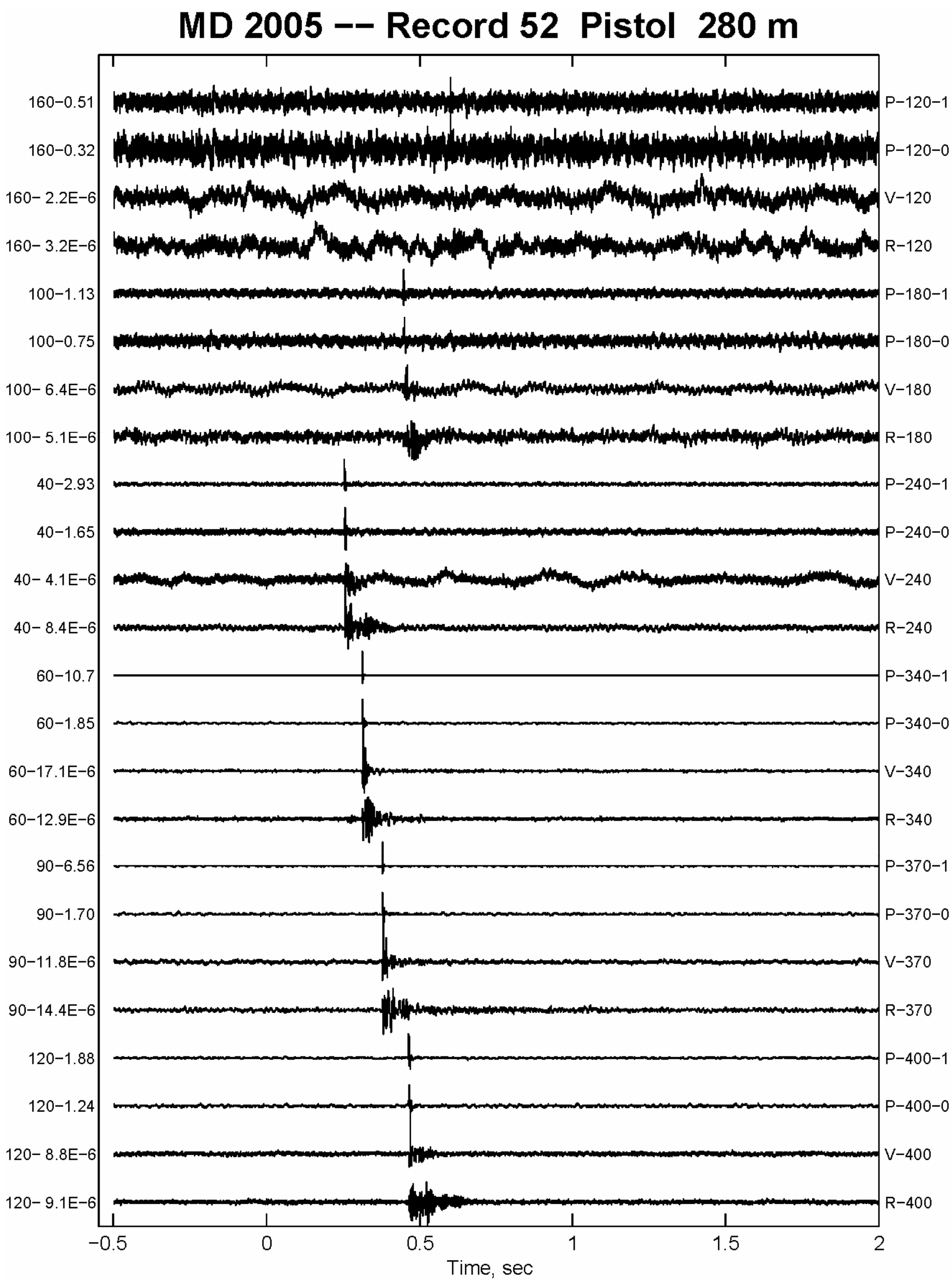
Pistol Data Plots



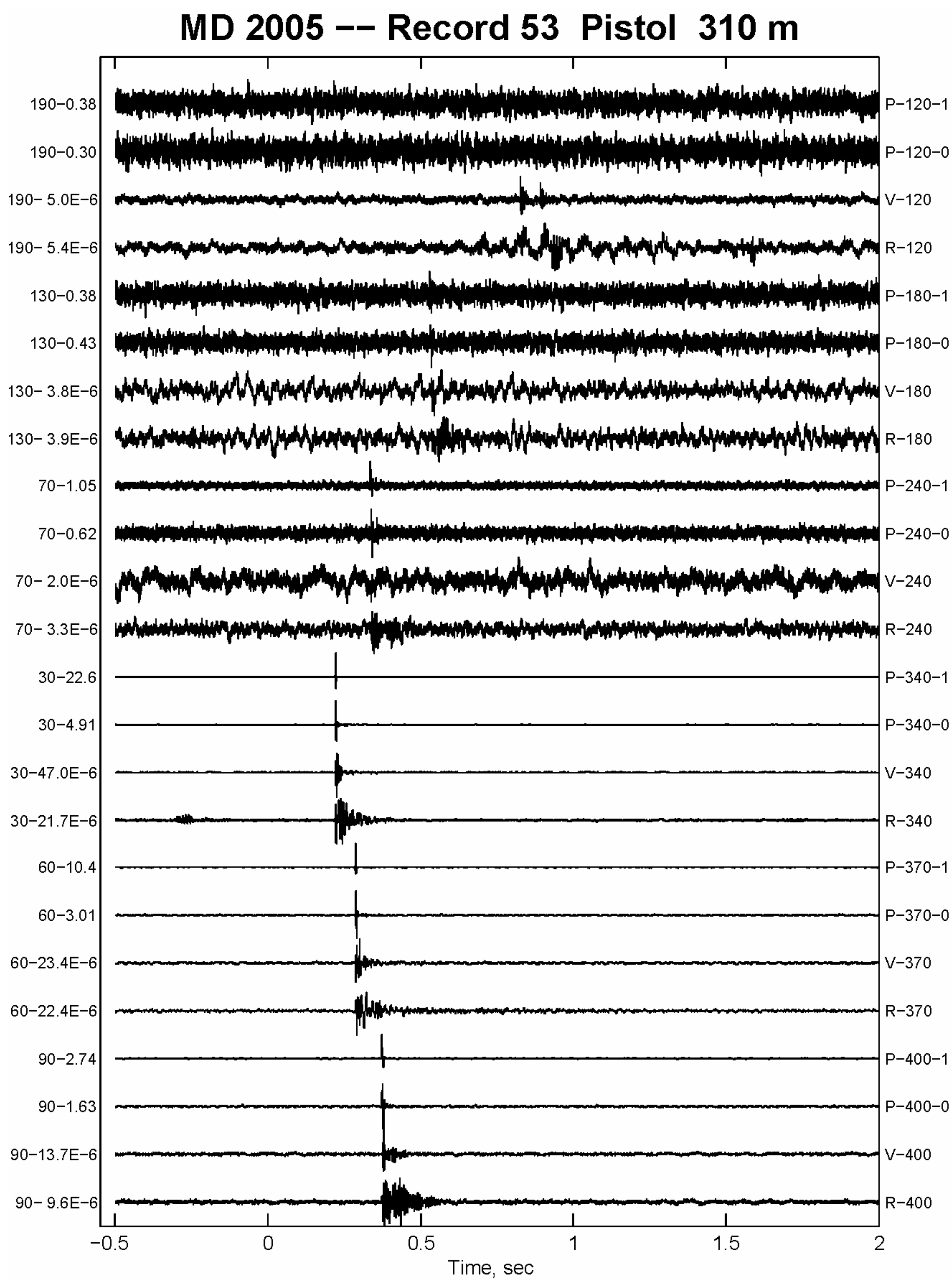

MD 2005 -- Record 49 Pistol 280 m
160−0.45
160−0.49
160− 1.2E−6
160− 3.7E−6
100−1.06
100−0.67
100− 6.0E−6
100− 5.2E−6
40−3.37
40−1.87
40− 3.9E−6
40− 8.6E−6
60−11.5
60−2.03
60−17.9E−6
60−14.0E−6
90−8.50
90−1.91
90−13.4E−6
90−15.1E−6
120−3.08
120−1.29
120− 9.0E−6
120− 8.7E−6
P−120−1
P−120−0
V−120
R−120
P−180−1
P−180−0
V−180
R−180
P−240−1
P−240−0
V−240
R−240
P−340−1
P−340−0
V−340
R−340
P−370−1
P−370−0
V−370
R−370
P−400−1
P−400−0
V−400
R−400
−0.5
0
0.5
1
1.5
2
Time, sec

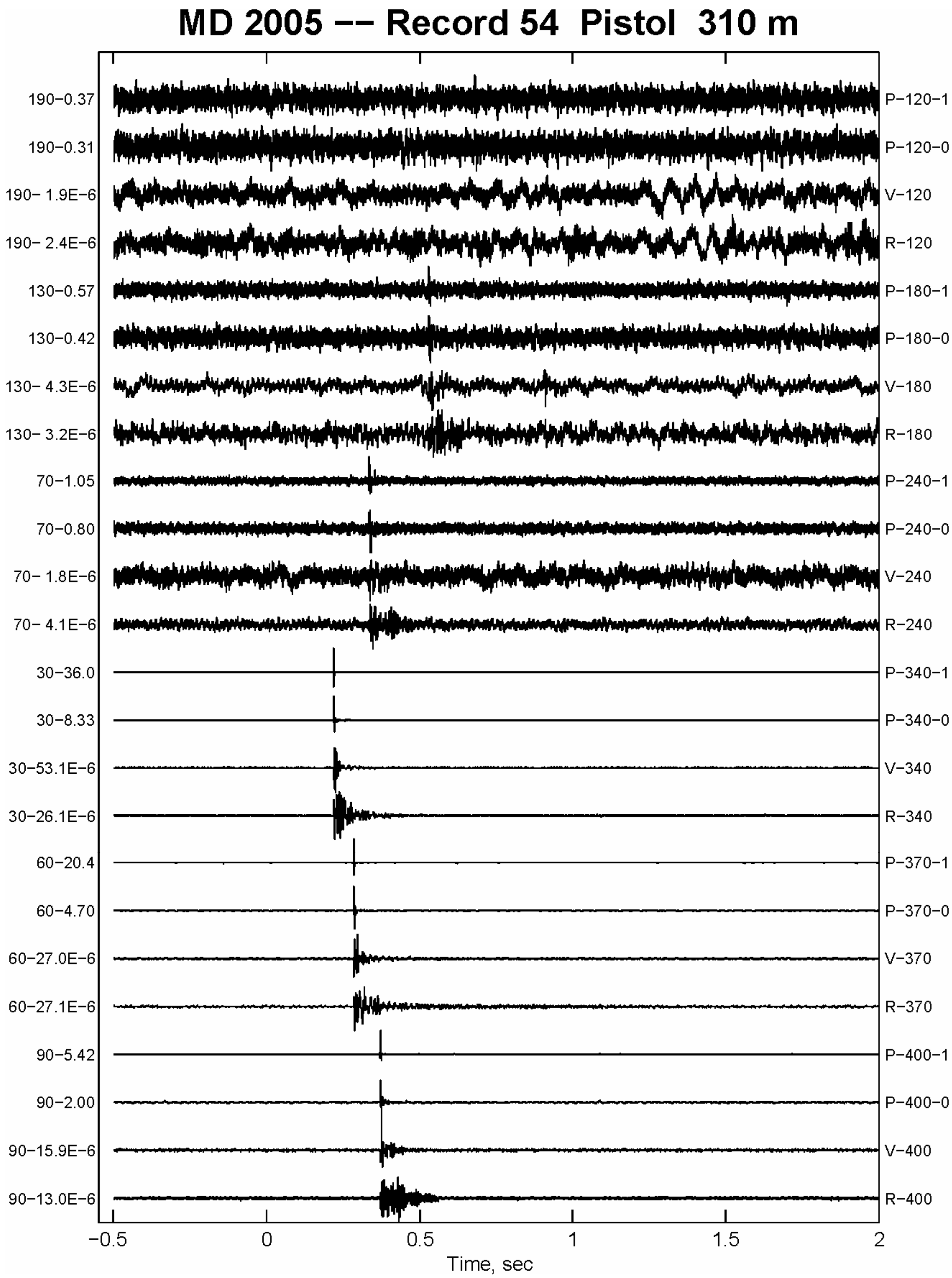

MD 2005 -- Record 50 Pistol 280 m
160−0.58
160−0.30
160− 1.3E−6
160− 1.9E−6
100−0.84
100−0.50
100− 4.6E−6
100− 4.7E−6
40−3.34
40−1.74
40− 4.5E−6
40− 8.6E−6
60−13.1
60−2.02
60−18.2E−6
60−12.9E−6
90−7.77
90−1.66
90−11.7E−6
90−13.5E−6
120−1.95
120−1.10
120− 8.1E−6
120− 7.7E−6
P−120−1
P−120−0
V−120
R−120
P−180−1
P−180−0
V−180
R−180
P−240−1
P−240−0
V−240
R−240
P−340−1
P−340−0
V−340
R−340
P−370−1
P−370−0
V−370
R−370
P−400−1
P−400−0
V−400
R−400
−0.5
0
0.5
1
1.5
2
Time, sec

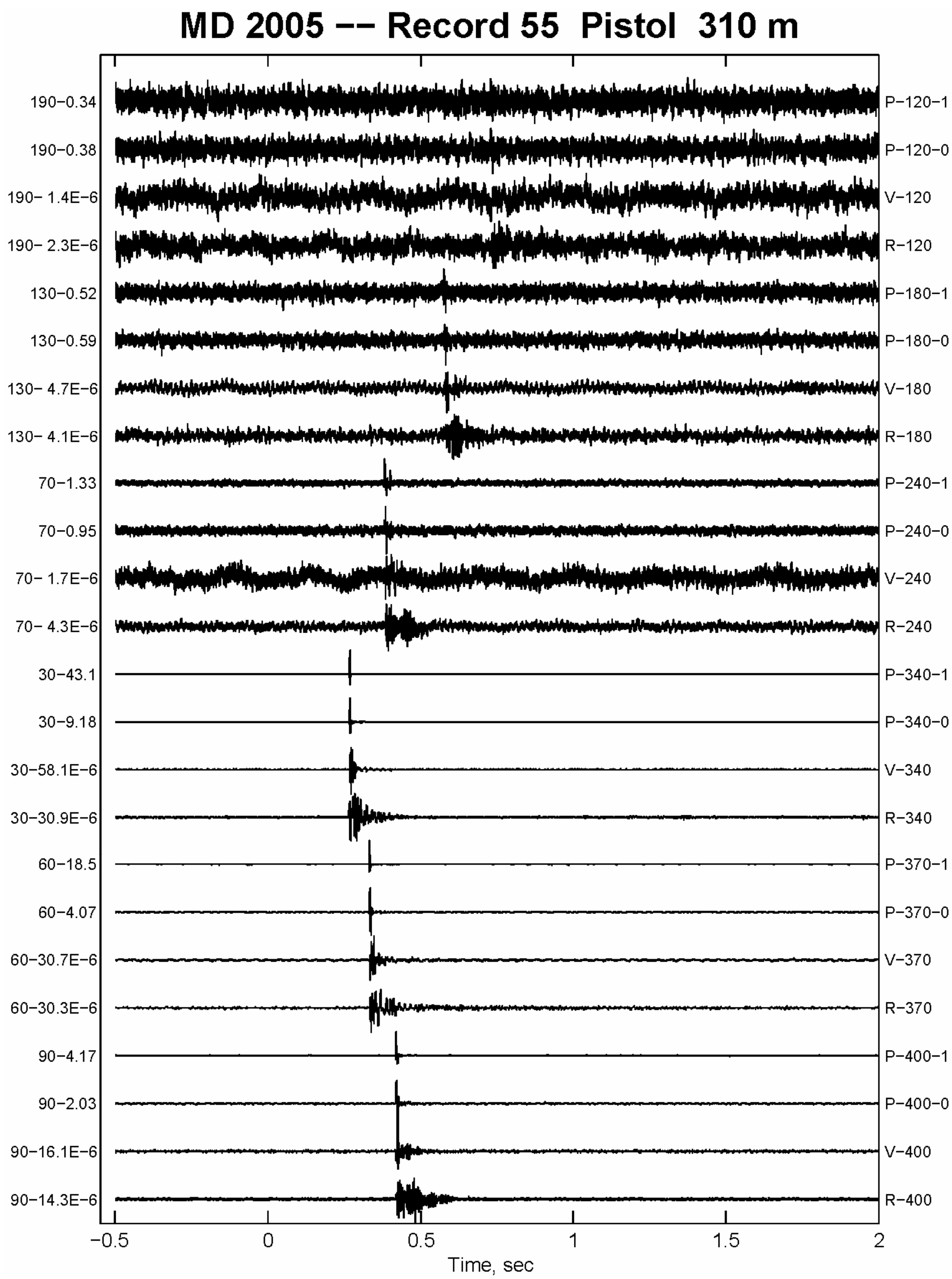

MD 2005 -- Record 51 Pistol 280 m
160−0.42
160−0.34
160− 1.8E−6
160− 2.5E−6
100−0.54
100−0.53
100− 5.6E−6
100− 4.6E−6
40−2.33
40−1.45
40− 5.5E−6
40− 8.2E−6
60−8.49
60−1.82
60−17.2E−6
60−11.7E−6
90−6.03
90−1.61
90−11.3E−6
90−12.7E−6
120−2.00
120−1.06
120− 8.0E−6
120− 8.5E−6
P−120−1
P−120−0
V−120
R−120
P−180−1
P−180−0
V−180
R−180
P−240−1
P−240−0
V−240
R−240
P−340−1
P−340−0
V−340
R−340
P−370−1
P−370−0
V−370
R−370
P−400−1
P−400−0
V−400
R−400
−0.5
0
0.5
1
1.5
2
Time, sec

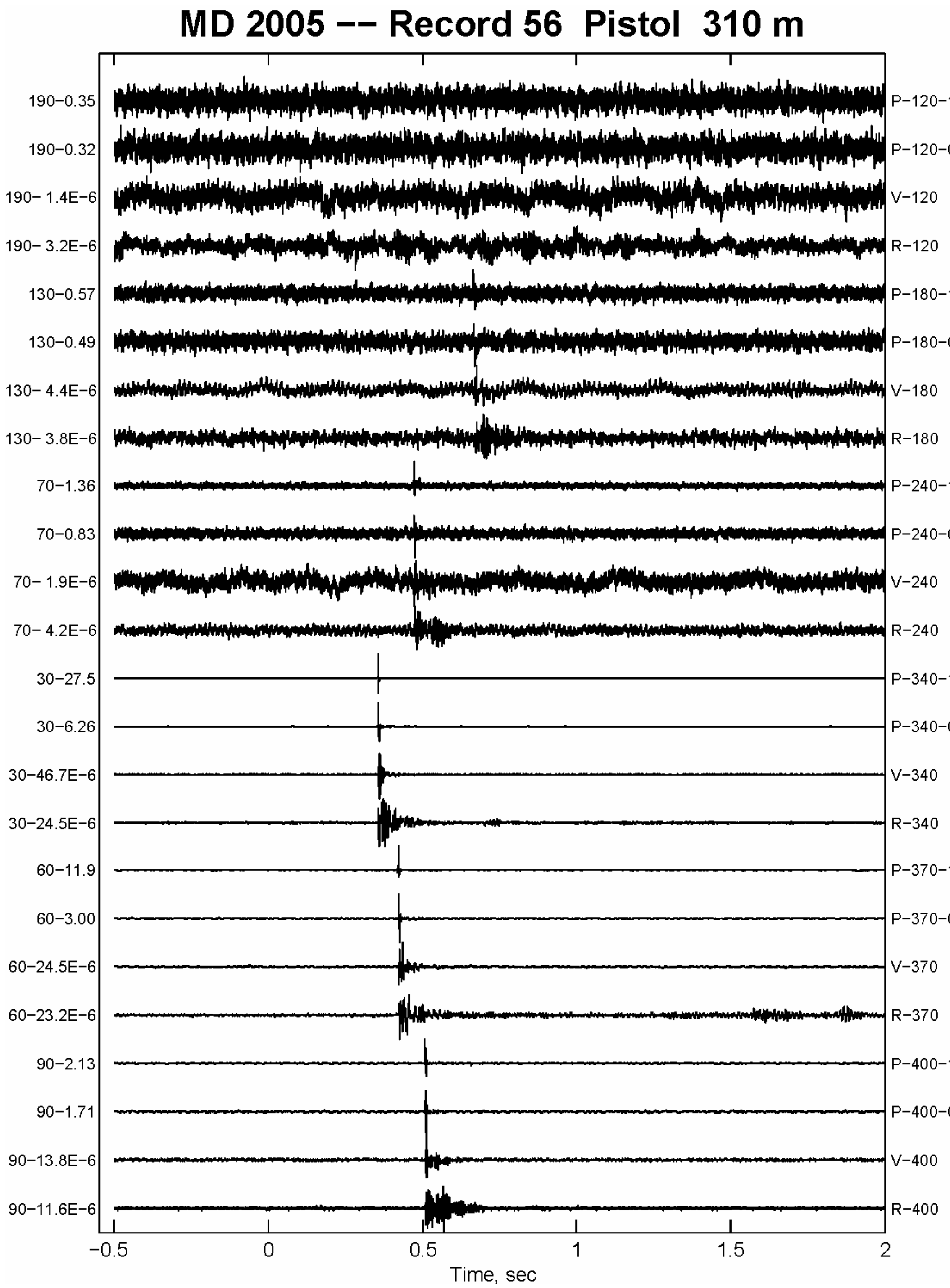


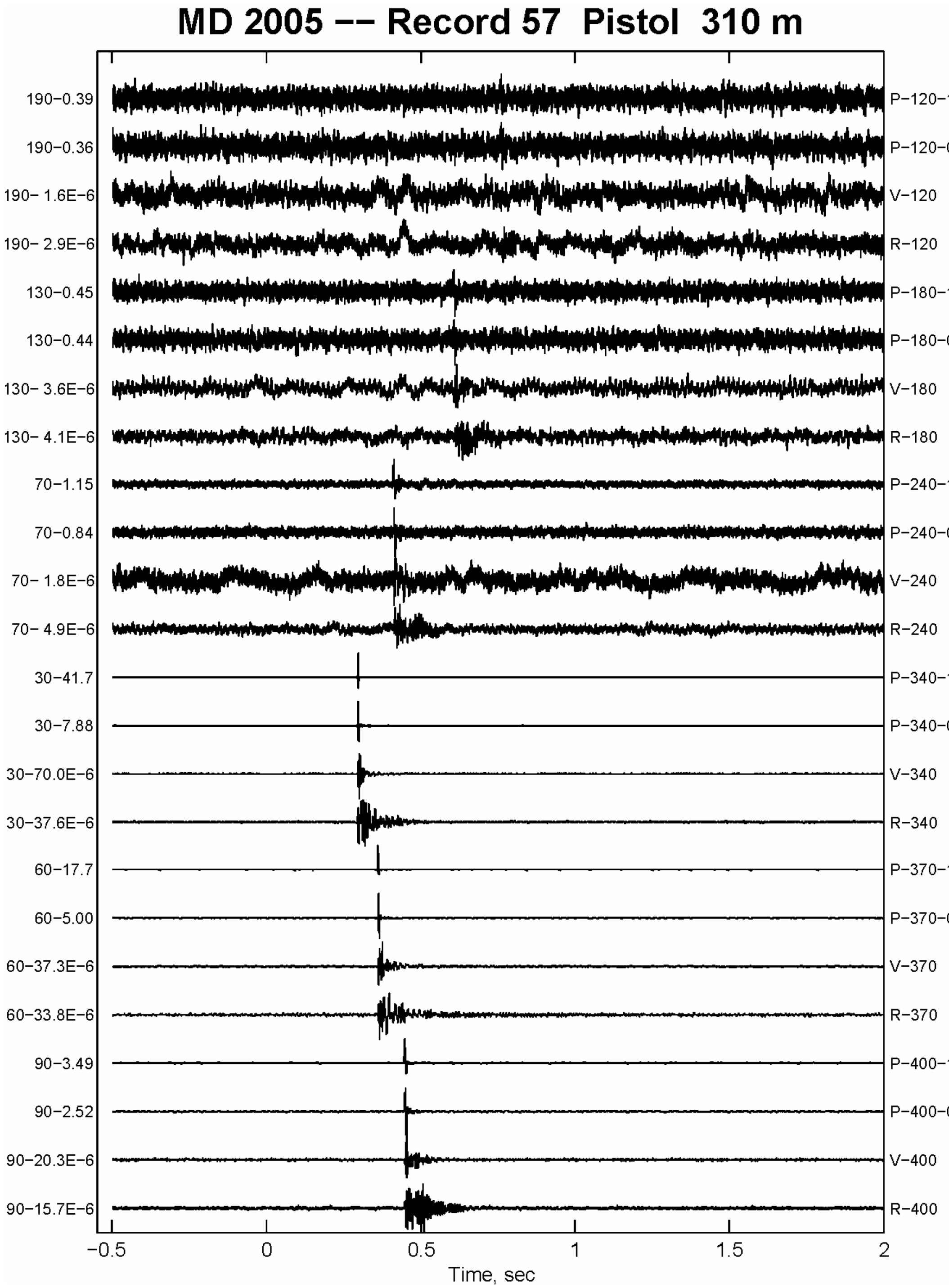
MD 2005 -- Record 52 Pistol 280 m
160−0.51
160−0.32
160− 2.2E−6
160− 3.2E−6
100−1.13
100−0.75
100− 6.4E−6
100− 5.1E−6
40−2.93
40−1.65
40− 4.1E−6
40− 8.4E−6
60−10.7
60−1.85
60−17.1E−6
60−12.9E−6
90−6.56
90−1.70
90−11.8E−6
90−14.4E−6
120−1.88
120−1.24
120− 8.8E−6
120− 9.1E−6
P−120−1
P−120−0
V−120
R−120
P−180−1
P−180−0
V−180
R−180
P−240−1
P−240−0
V−240
R−240
P−340−1
P−340−0
V−340
R−340
P−370−1
P−370−0
V−370
R−370
P−400−1
P−400−0
V−400
R−400
−0.5
0
0.5
1
1.5
2
Time, sec

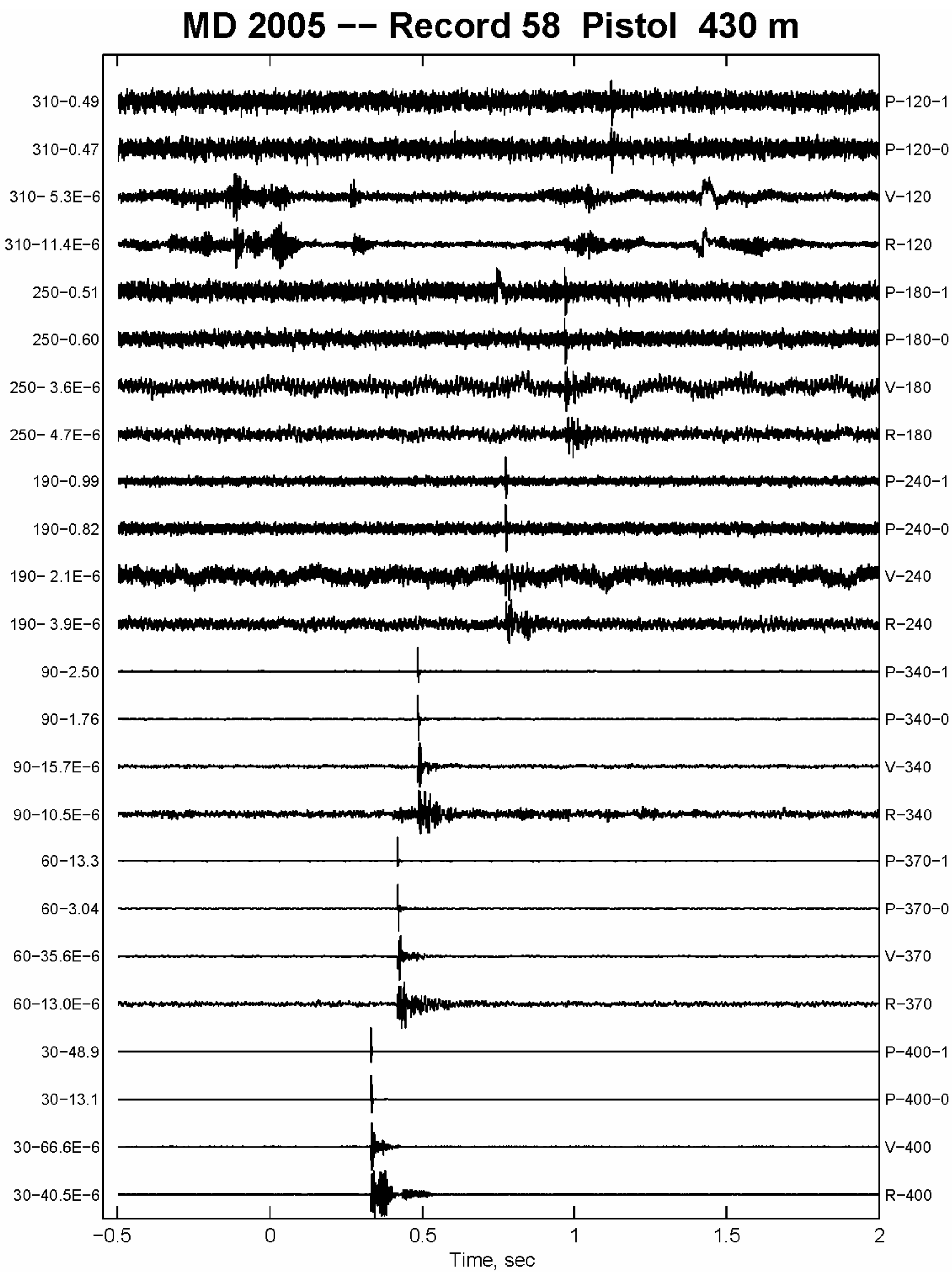

MD 2005 -- Record 53 Pistol 310 m
190−0.38
190−0.30
190− 5.0E−6
190− 5.4E−6
130−0.38
130−0.43
130− 3.8E−6
130− 3.9E−6
70−1.05
70−0.62
70− 2.0E−6
70− 3.3E−6
30−22.6
30−4.91
30−47.0E−6
30−21.7E−6
60−10.4
60−3.01
60−23.4E−6
60−22.4E−6
90−2.74
90−1.63
90−13.7E−6
90− 9.6E−6
P−120−1
P−120−0
V−120
R−120
P−180−1
P−180−0
V−180
R−180
P−240−1
P−240−0
V−240
R−240
P−340−1
P−340−0
V−340
R−340
P−370−1
P−370−0
V−370
R−370
P−400−1
P−400−0
V−400
R−400
−0.5
0
0.5
1
1.5
2
Time, sec

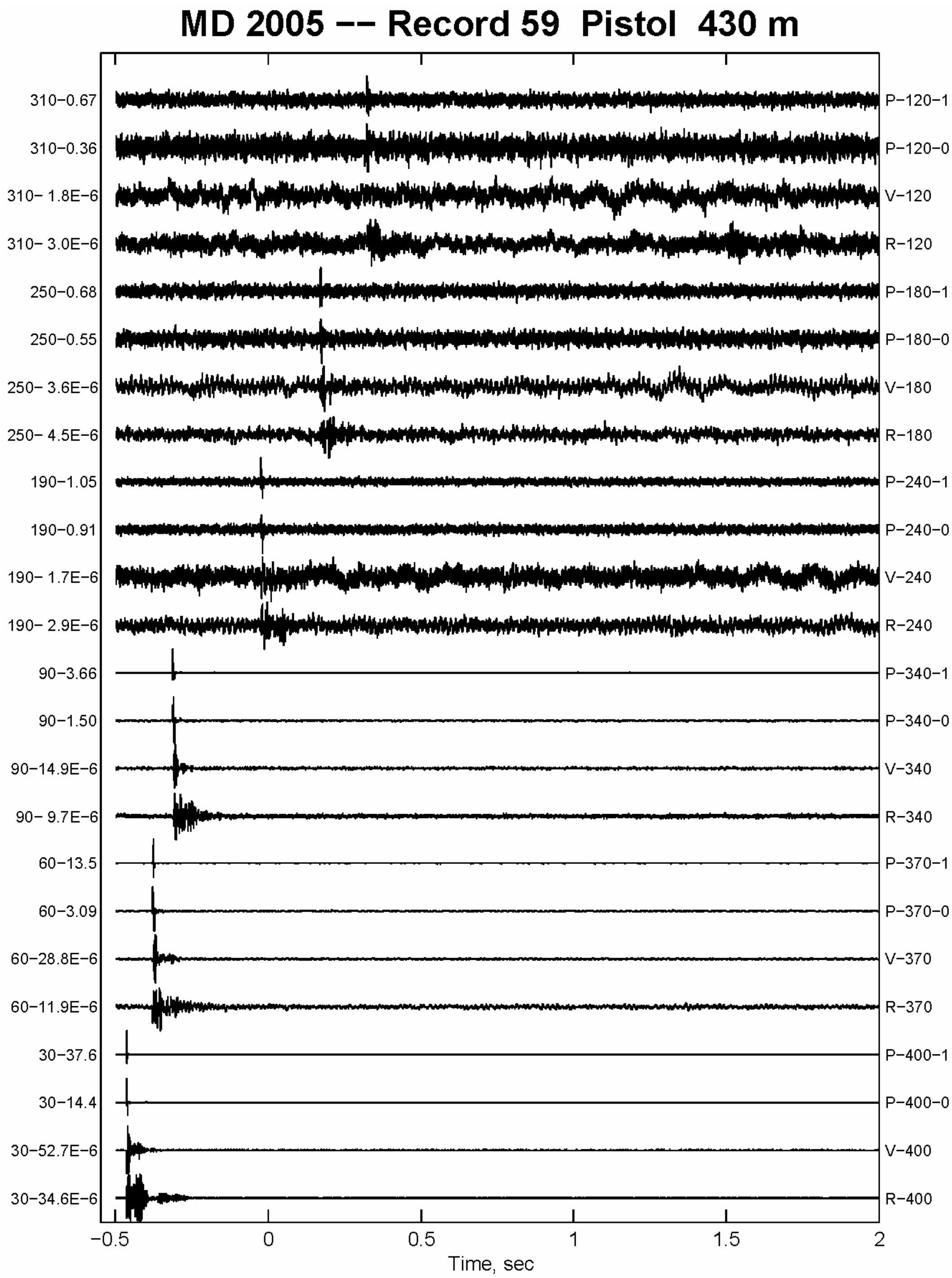

MD 2005 -- Record 54 Pistol 310 m
190−0.37
190−0.31
190− 1.9E−6
190− 2.4E−6
130−0.57
130−0.42
130− 4.3E−6
130− 3.2E−6
70−1.05
70−0.80
70− 1.8E−6
70− 4.1E−6
30−36.0
30−8.33
30−53.1E−6
30−26.1E−6
60−20.4
60−4.70
60−27.0E−6
60−27.1E−6
90−5.42
90−2.00
90−15.9E−6
90−13.0E−6
P−120−1
P−120−0
V−120
R−120
P−180−1
P−180−0
V−180
R−180
P−240−1
P−240−0
V−240
R−240
P−340−1
P−340−0
V−340
R−340
P−370−1
P−370−0
V−370
R−370
P−400−1
P−400−0
V−400
R−400
−0.5
0
0.5
1
1.5
2
Time, sec

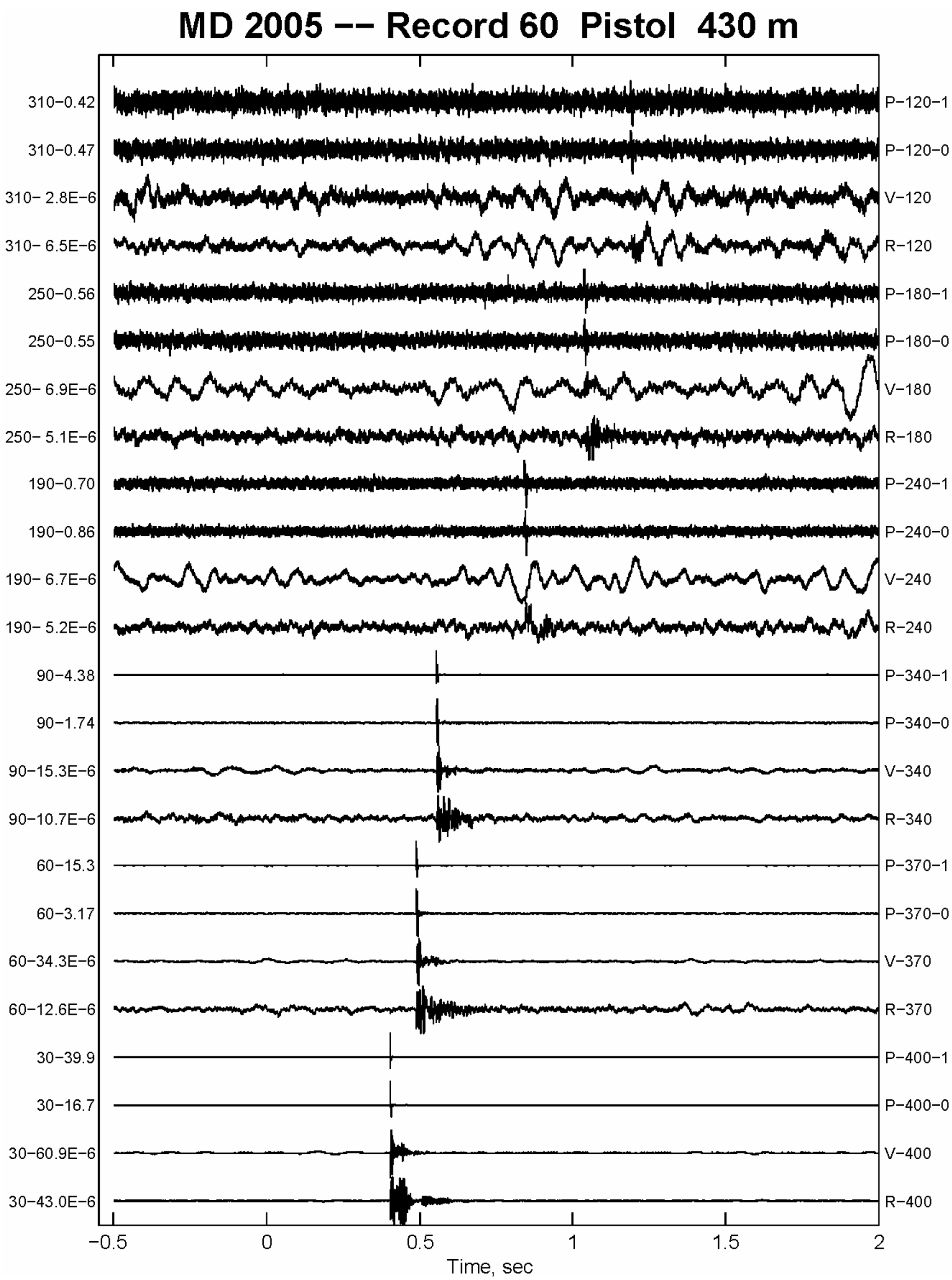

MD 2005 -- Record 55 Pistol 310 m
190−0.34
190−0.38
190− 1.4E−6
190− 2.3E−6
130−0.52
130−0.59
130− 4.7E−6
130− 4.1E−6
70−1.33
70−0.95
70− 1.7E−6
70− 4.3E−6
30−43.1
30−9.18
30−58.1E−6
30−30.9E−6
60−18.5
60−4.07
60−30.7E−6
60−30.3E−6
90−4.17
90−2.03
90−16.1E−6
90−14.3E−6
P−120−1
P−120−0
V−120
R−120
P−180−1
P−180−0
V−180
R−180
P−240−1
P−240−0
V−240
R−240
P−340−1
P−340−0
V−340
R−340
P−370−1
P−370−0
V−370
R−370
P−400−1
P−400−0
V−400
R−400
−0.5
0
0.5
1
1.5
2
Time, sec

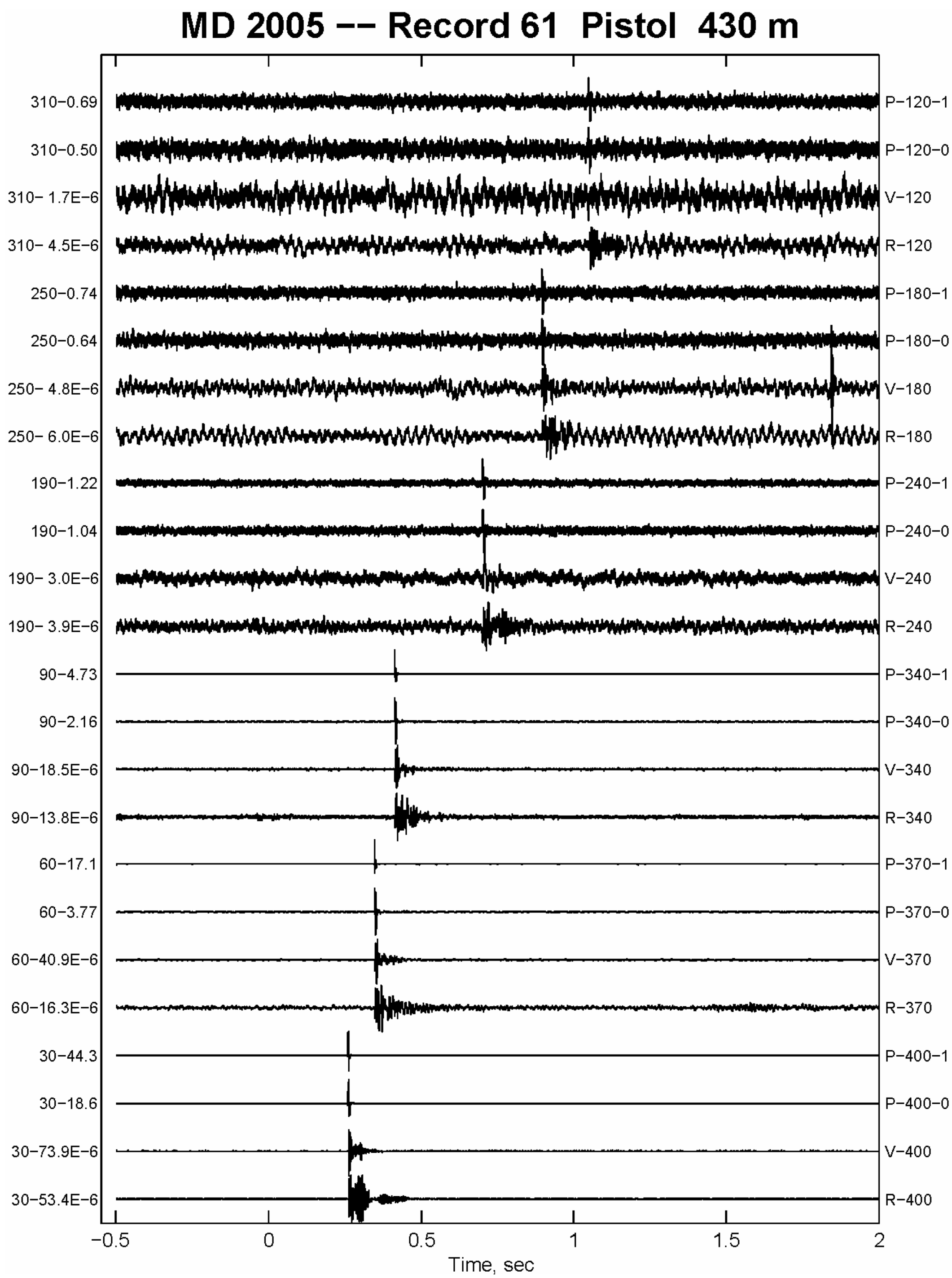

MD 2005 -- Record 56 Pistol 310 m
190−0.35
190−0.32
190− 1.4E−6
190− 3.2E−6
130−0.57
130−0.49
130− 4.4E−6
130− 3.8E−6
70−1.36
70−0.83
70− 1.9E−6
70− 4.2E−6
30−27.5
30−6.26
30−46.7E−6
30−24.5E−6
60−11.9
60−3.00
60−24.5E−6
60−23.2E−6
90−2.13
90−1.71
90−13.8E−6
90−11.6E−6
P−120−1
P−120−0
V−120
R−120
P−180−1
P−180−0
V−180
R−180
P−240−1
P−240−0
V−240
R−240
P−340−1
P−340−0
V−340
R−340
P−370−1
P−370−0
V−370
R−370
P−400−1
P−400−0
V−400
R−400
−0.5
0
0.5
1
1.5
2
Time, sec

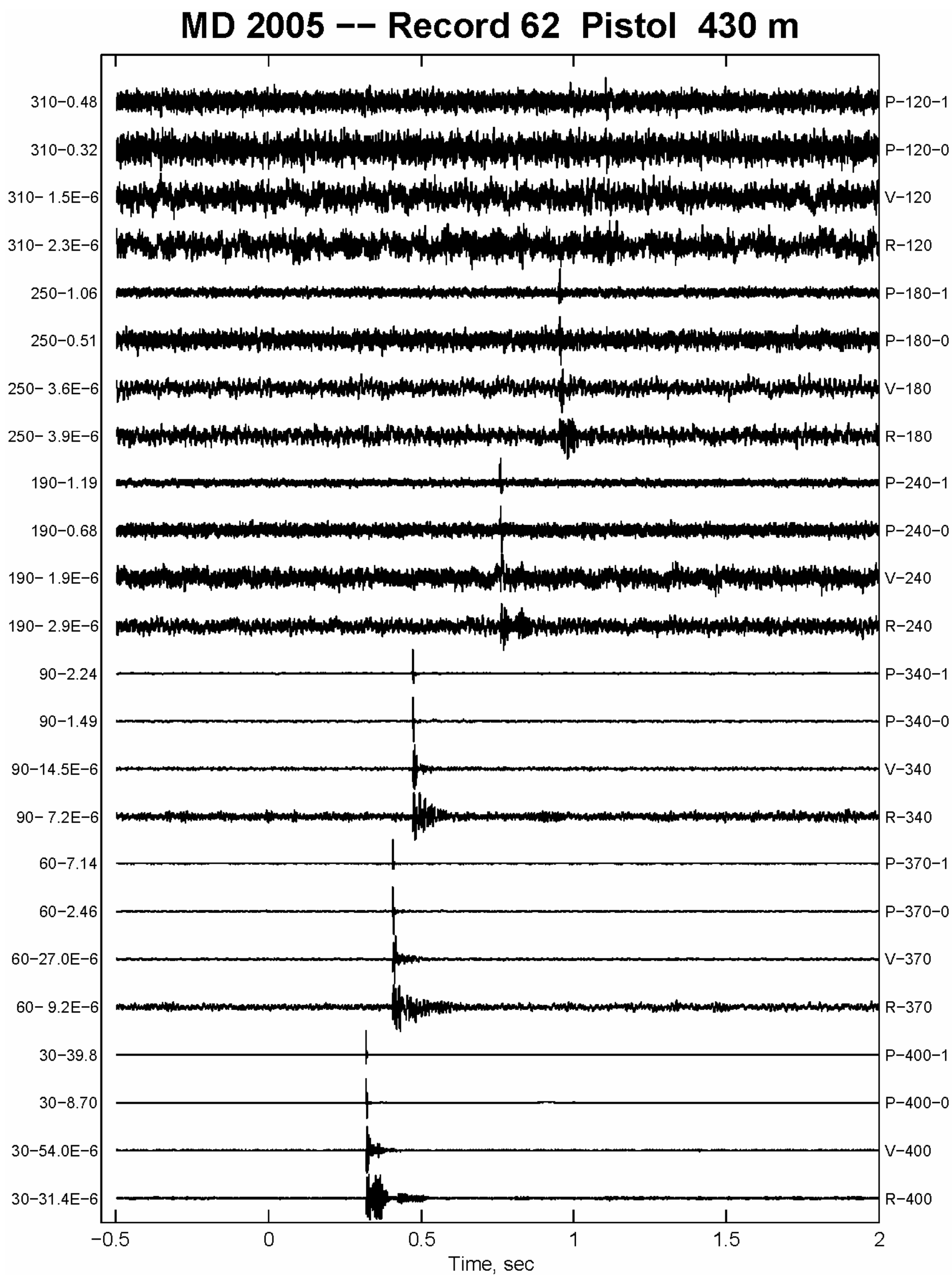

MD 2005 -- Record 57 Pistol 310 m
190−0.39
190−0.36
190− 1.6E−6
190− 2.9E−6
130−0.45
130−0.44
130− 3.6E−6
130− 4.1E−6
70−1.15
70−0.84
70− 1.8E−6
70− 4.9E−6
30−41.7
30−7.88
30−70.0E−6
30−37.6E−6
60−17.7
60−5.00
60−37.3E−6
60−33.8E−6
90−3.49
90−2.52
90−20.3E−6
90−15.7E−6
P−120−1
P−120−0
V−120
R−120
P−180−1
P−180−0
V−180
R−180
P−240−1
P−240−0
V−240
R−240
P−340−1
P−340−0
V−340
R−340
P−370−1
P−370−0
V−370
R−370
P−400−1
P−400−0
V−400
R−400
−0.5
0
0.5
1
1.5
2
Time, sec

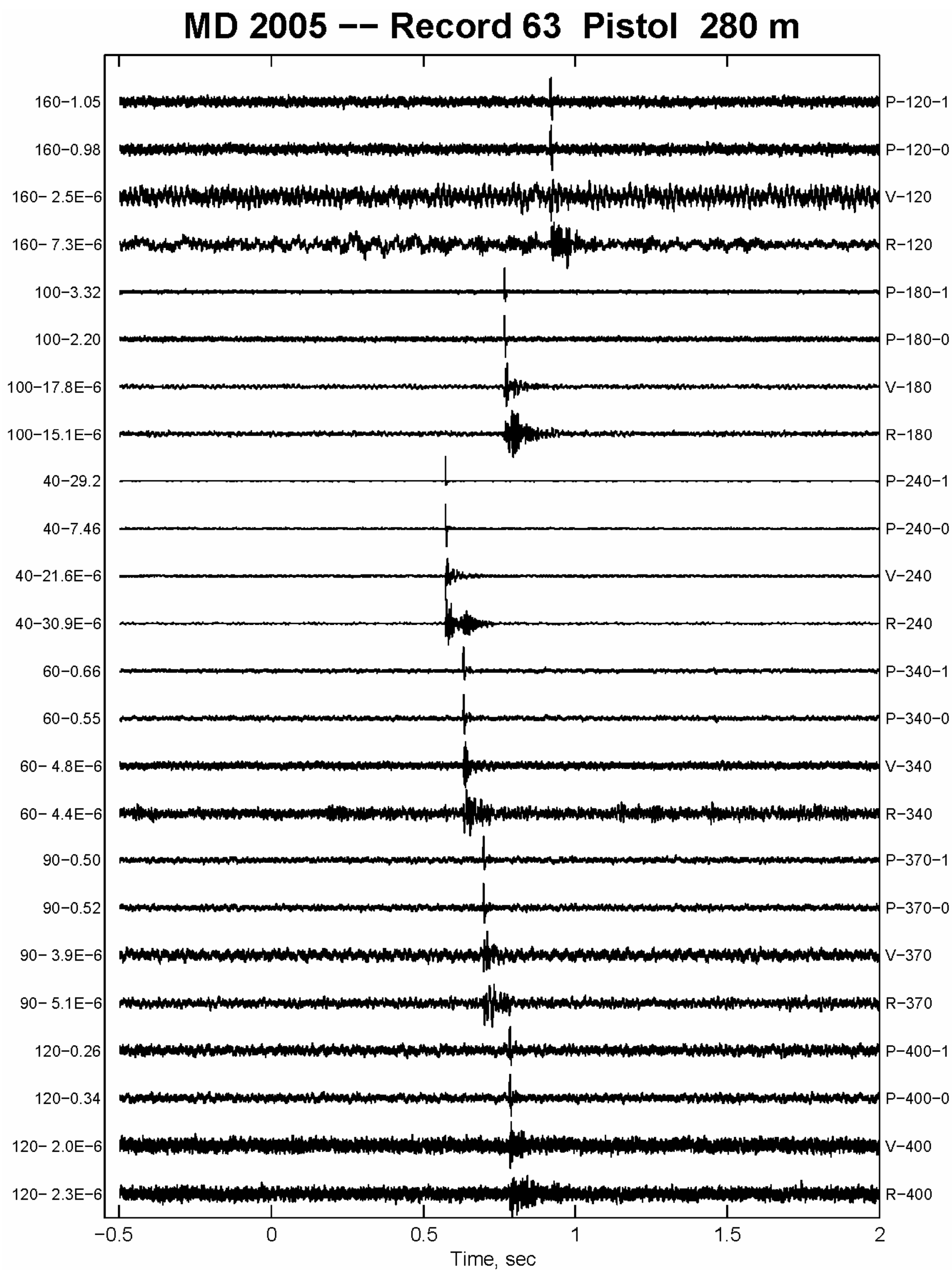

MD 2005 -- Record 58 Pistol 430 m
310−0.49
310−0.47
310− 5.3E−6
310−11.4E−6
250−0.51
250−0.60
250− 3.6E−6
250− 4.7E−6
190−0.99
190−0.82
190− 2.1E−6
190− 3.9E−6
90−2.50
90−1.76
90−15.7E−6
90−10.5E−6
60−13.3
60−3.04
60−35.6E−6
60−13.0E−6
30−48.9
30−13.1
30−66.6E−6
30−40.5E−6
P−120−1
P−120−0
V−120
R−120
P−180−1
P−180−0
V−180
R−180
P−240−1
P−240−0
V−240
R−240
P−340−1
P−340−0
V−340
R−340
P−370−1
P−370−0
V−370
R−370
P−400−1
P−400−0
V−400
R−400
−0.5
0
0.5
1
1.5
2
Time, sec


MD 2005 -- Record 59 Pistol 430 m
310−0.67
310−0.36
310− 1.8E−6
310− 3.0E−6
250−0.68
250−0.55
250− 3.6E−6
250− 4.5E−6
190−1.05
190−0.91
190− 1.7E−6
190− 2.9E−6
90−3.66
90−1.50
90−14.9E−6
90− 9.7E−6
60−13.5
60−3.09
60−28.8E−6
60−11.9E−6
30−37.6
30−14.4
30−52.7E−6
30−34.6E−6
P−120−1
P−120−0
V−120
R−120
P−180−1
P−180−0
V−180
R−180
P−240−1
P−240−0
V−240
R−240
P−340−1
P−340−0
V−340
R−340
P−370−1
P−370−0
V−370
R−370
P−400−1
P−400−0
V−400
R−400
−0.5
0
0.5
1
1.5
2
Time, sec

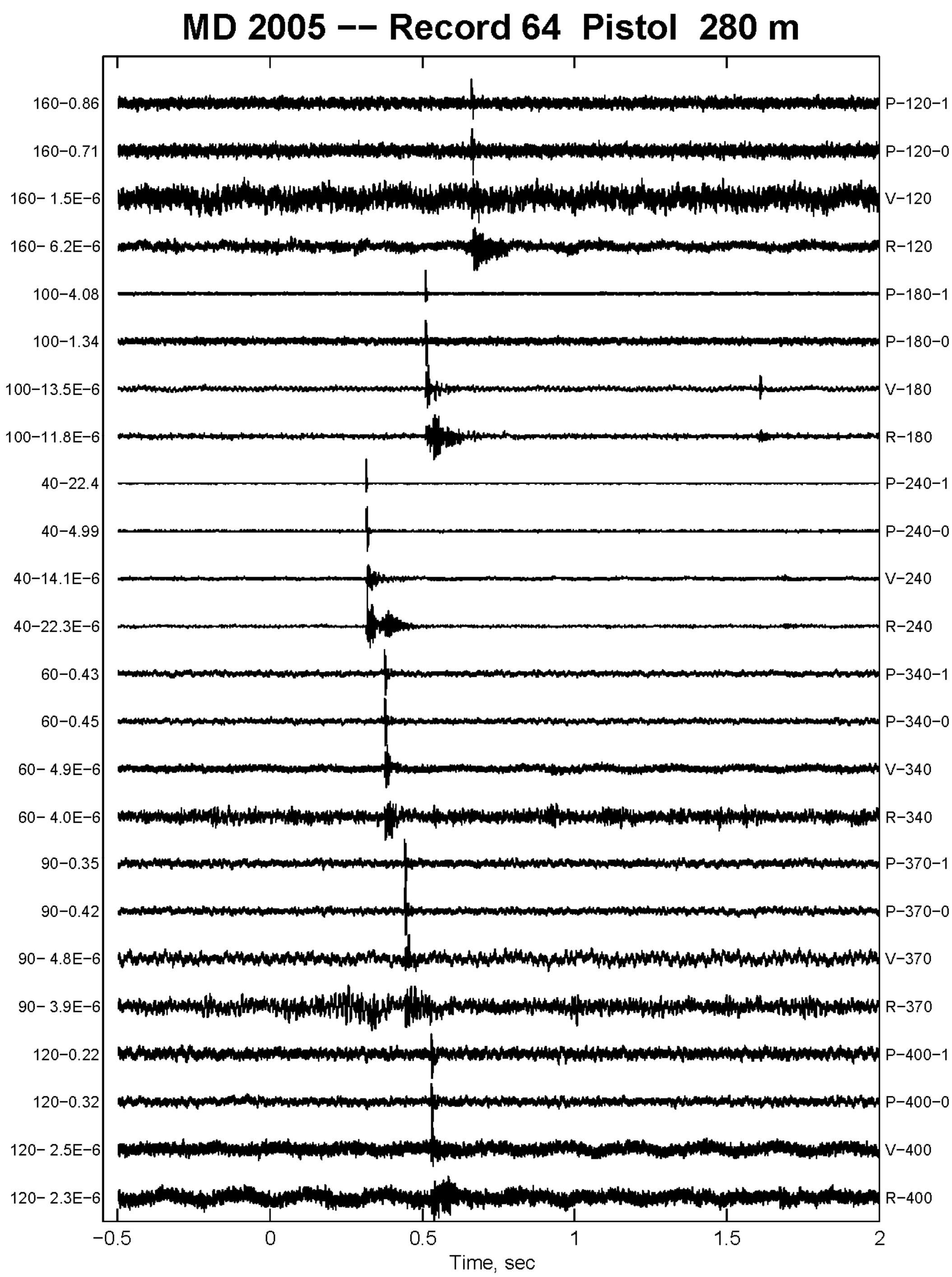

MD 2005 -- Record 60 Pistol 430 m
310−0.42
310−0.47
310− 2.8E−6
310− 6.5E−6
250−0.56
250−0.55
250− 6.9E−6
250− 5.1E−6
190−0.70
190−0.86
190− 6.7E−6
190− 5.2E−6
90−4.38
90−1.74
90−15.3E−6
90−10.7E−6
60−15.3
60−3.17
60−34.3E−6
60−12.6E−6
30−39.9
30−16.7
30−60.9E−6
30−43.0E−6
P−120−1
P−120−0
V−120
R−120
P−180−1
P−180−0
V−180
R−180
P−240−1
P−240−0
V−240
R−240
P−340−1
P−340−0
V−340
R−340
P−370−1
P−370−0
V−370
R−370
P−400−1
P−400−0
V−400
R−400
−0.5
0
0.5
1
1.5
2
Time, sec

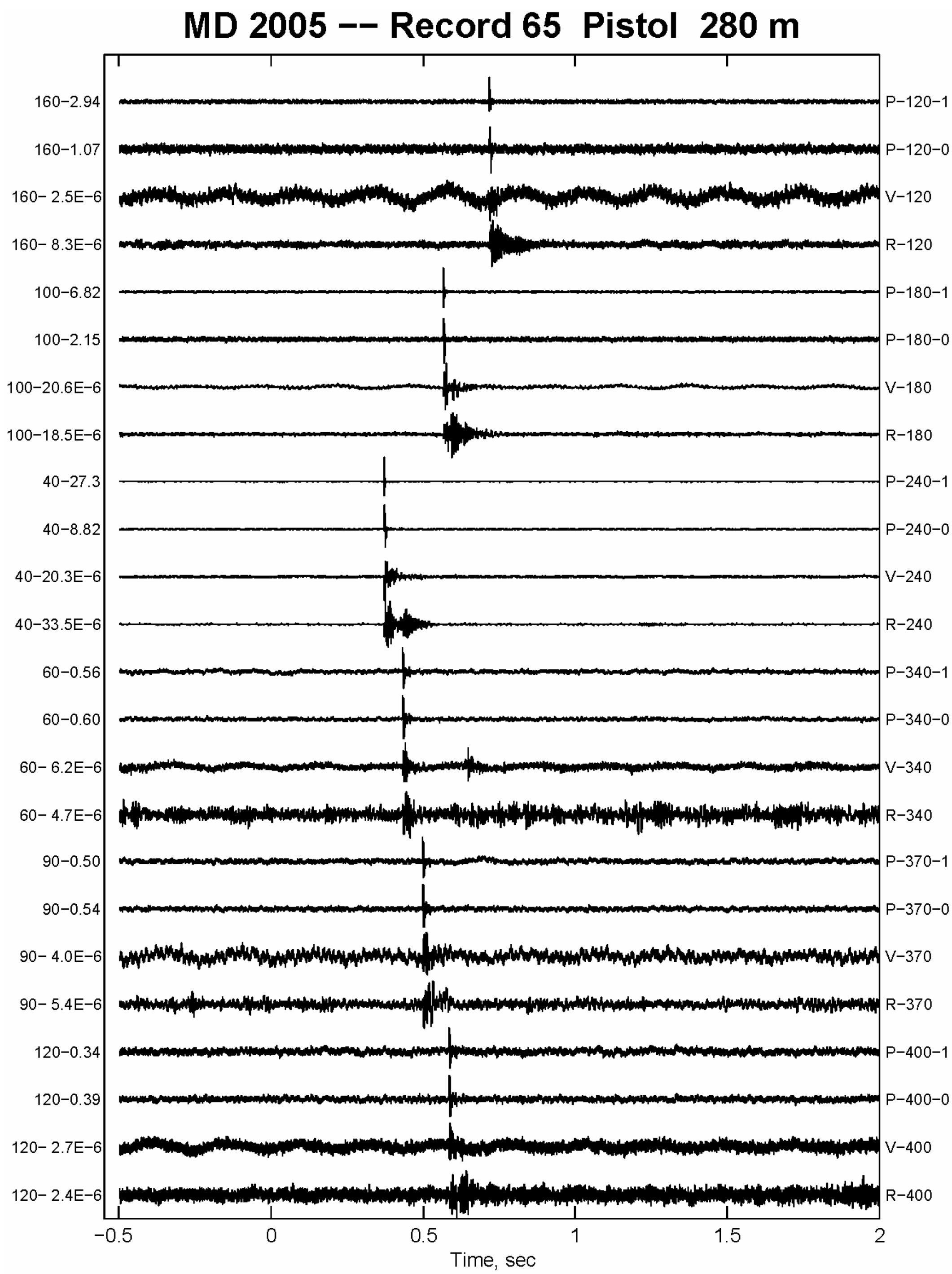

MD 2005 -- Record 61 Pistol 430 m
310−0.69
310−0.50
310− 1.7E−6
310− 4.5E−6
250−0.74
250−0.64
250− 4.8E−6
250− 6.0E−6
190−1.22
190−1.04
190− 3.0E−6
190− 3.9E−6
90−4.73
90−2.16
90−18.5E−6
90−13.8E−6
60−17.1
60−3.77
60−40.9E−6
60−16.3E−6
30−44.3
30−18.6
30−73.9E−6
30−53.4E−6
P−120−1
P−120−0
V−120
R−120
P−180−1
P−180−0
V−180
R−180
P−240−1
P−240−0
V−240
R−240
P−340−1
P−340−0
V−340
R−340
P−370−1
P−370−0
V−370
R−370
P−400−1
P−400−0
V−400
R−400
−0.5
0
0.5
1
1.5
2
Time, sec

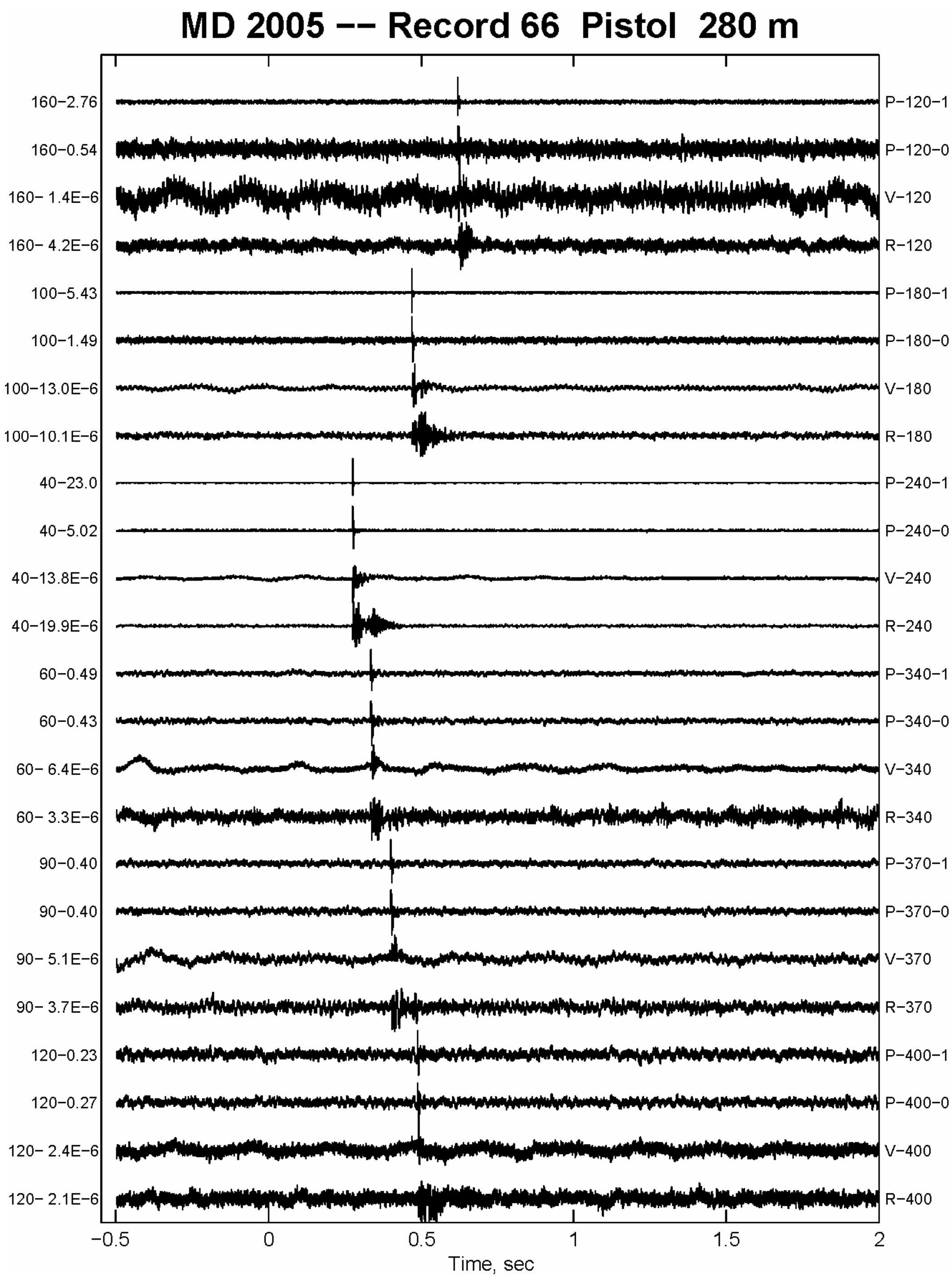

MD 2005 -- Record 62 Pistol 430 m
310−0.48
310−0.32
310− 1.5E−6
310− 2.3E−6
250−1.06
250−0.51
250− 3.6E−6
250− 3.9E−6
190−1.19
190−0.68
190− 1.9E−6
190− 2.9E−6
90−2.24
90−1.49
90−14.5E−6
90− 7.2E−6
60−7.14
60−2.46
60−27.0E−6
60− 9.2E−6
30−39.8
30−8.70
30−54.0E−6
30−31.4E−6
P−120−1
P−120−0
V−120
R−120
P−180−1
P−180−0
V−180
R−180
P−240−1
P−240−0
V−240
R−240
P−340−1
P−340−0
V−340
R−340
P−370−1
P−370−0
V−370
R−370
P−400−1
P−400−0
V−400
R−400
−0.5
0
0.5
1
1.5
2
Time, sec

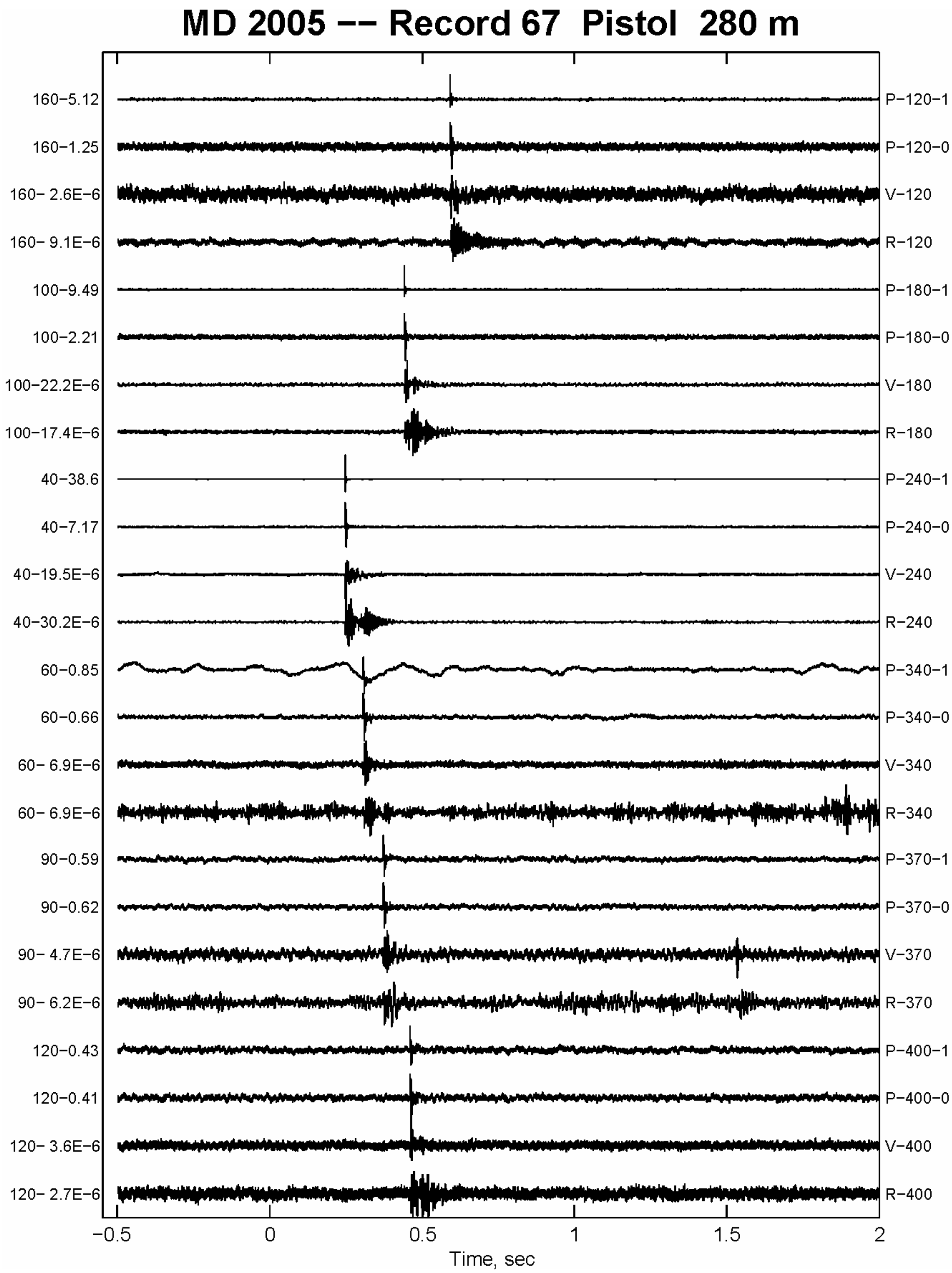


MD 2005 -- Record 63 Pistol 280 m
160−1.05
160−0.98
160− 2.5E−6
160− 7.3E−6
100−3.32
100−2.20
100−17.8E−6
100−15.1E−6
40−29.2
40−7.46
40−21.6E−6
40−30.9E−6
60−0.66
60−0.55
60− 4.8E−6
60− 4.4E−6
90−0.50
90−0.52
90− 3.9E−6
90− 5.1E−6
120−0.26
120−0.34
120− 2.0E−6
120− 2.3E−6
P−120−1
P−120−0
V−120
R−120
P−180−1
P−180−0
V−180
R−180
P−240−1
P−240−0
V−240
R−240
P−340−1
P−340−0
V−340
R−340
P−370−1
P−370−0
V−370
R−370
P−400−1
P−400−0
V−400
R−400
−0.5
0
0.5
1
1.5
2
Time, sec

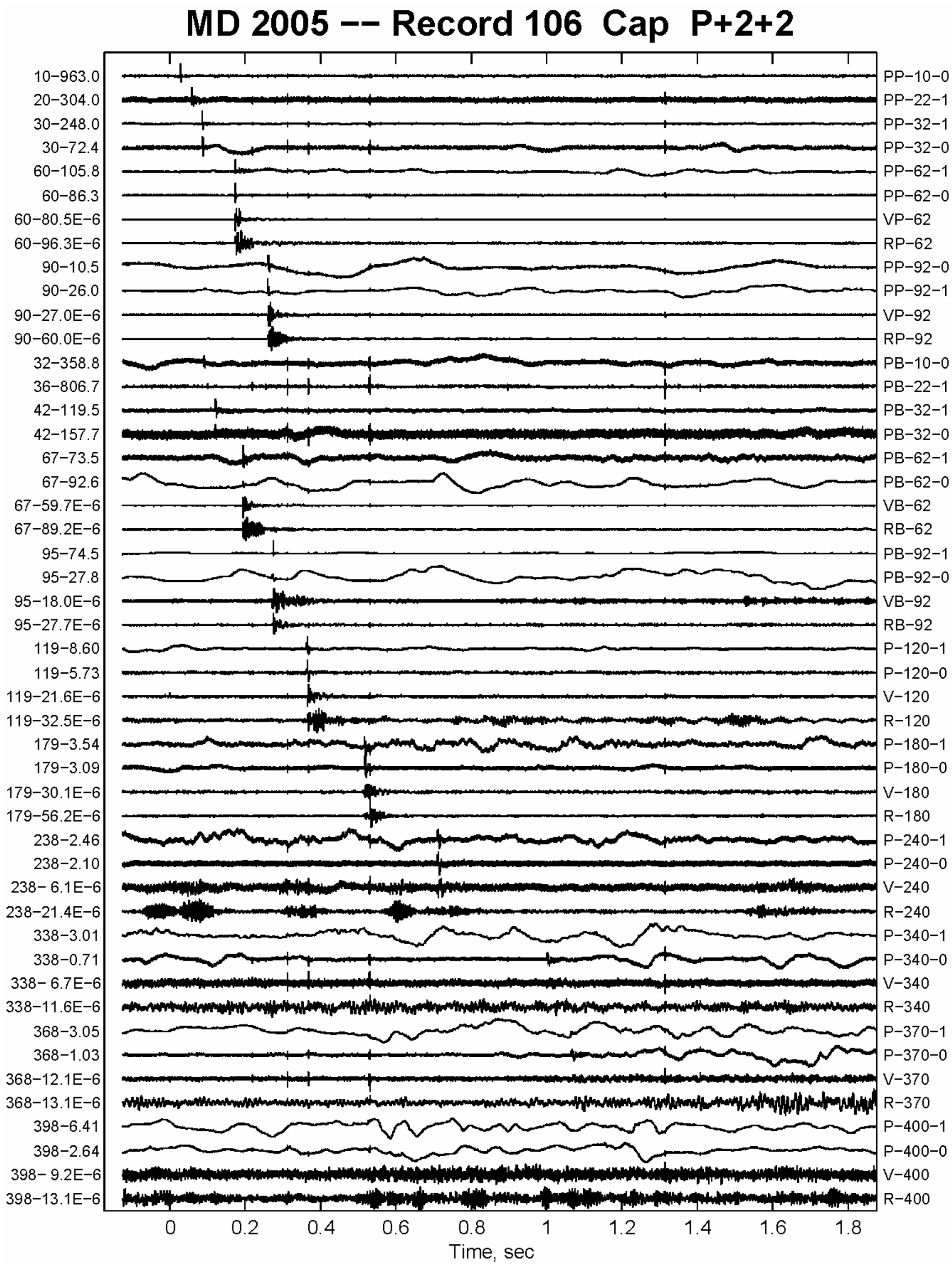

MD 2005 -- Record 64 Pistol 280 m
160−0.86
160−0.71
160− 1.5E−6
160− 6.2E−6
100−4.08
100−1.34
100−13.5E−6
100−11.8E−6
40−22.4
40−4.99
40−14.1E−6
40−22.3E−6
60−0.43
60−0.45
60− 4.9E−6
60− 4.0E−6
90−0.35
90−0.42
90− 4.8E−6
90− 3.9E−6
120−0.22
120−0.32
120− 2.5E−6
120− 2.3E−6
P−120−1
P−120−0
V−120
R−120
P−180−1
P−180−0
V−180
R−180
P−240−1
P−240−0
V−240
R−240
P−340−1
P−340−0
V−340
R−340
P−370−1
P−370−0
V−370
R−370
P−400−1
P−400−0
V−400
R−400
−0.5
0
0.5
1
1.5
2
Time, sec

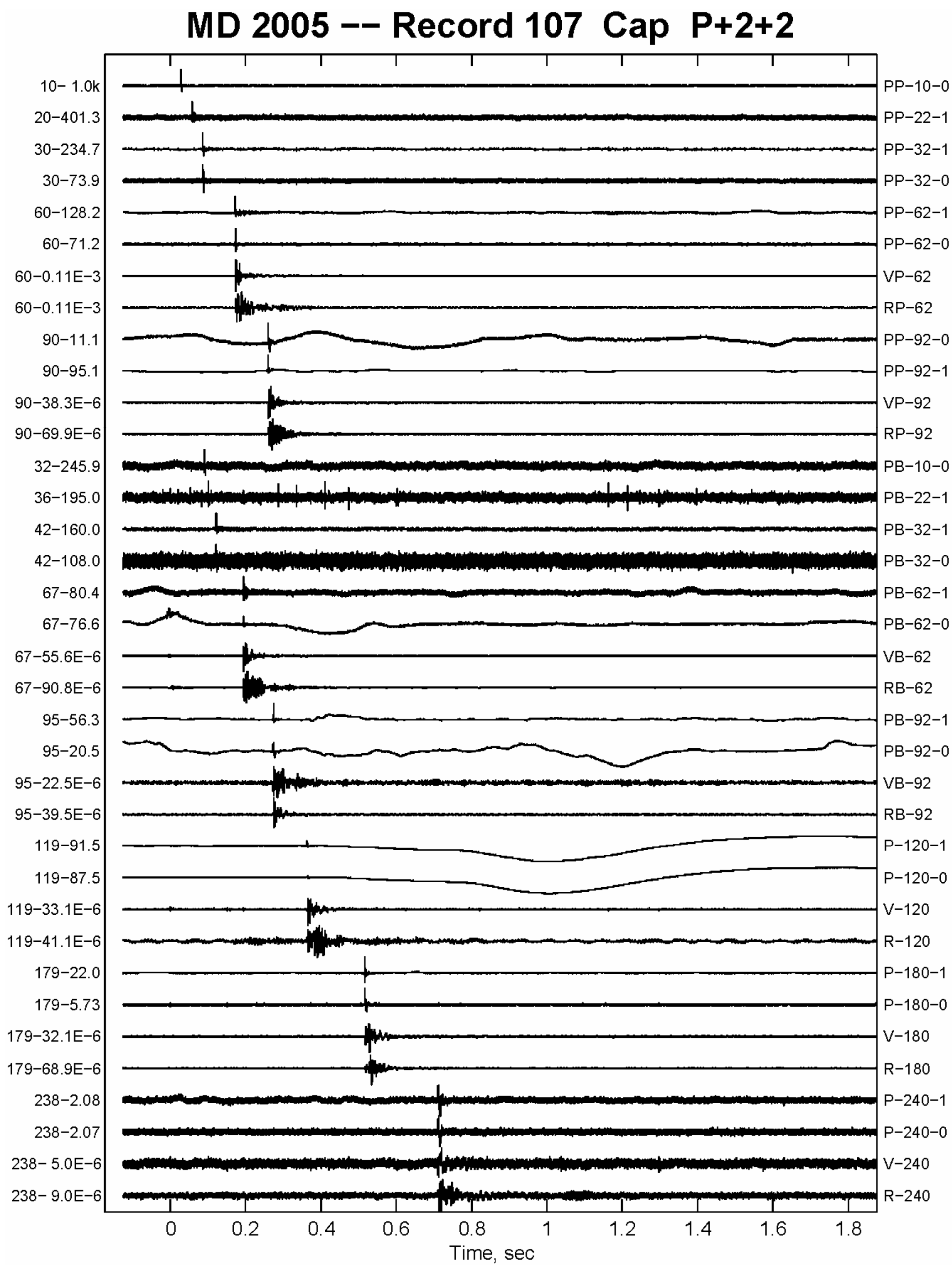

MD 2005 -- Record 65 Pistol 280 m
160−2.94
160−1.07
160− 2.5E−6
160− 8.3E−6
100−6.82
100−2.15
100−20.6E−6
100−18.5E−6
40−27.3
40−8.82
40−20.3E−6
40−33.5E−6
60−0.56
60−0.60
60− 6.2E−6
60− 4.7E−6
90−0.50
90−0.54
90− 4.0E−6
90− 5.4E−6
120−0.34
120−0.39
120− 2.7E−6
120− 2.4E−6
P−120−1
P−120−0
V−120
R−120
P−180−1
P−180−0
V−180
R−180
P−240−1
P−240−0
V−240
R−240
P−340−1
P−340−0
V−340
R−340
P−370−1
P−370−0
V−370
R−370
P−400−1
P−400−0
V−400
R−400
−0.5
0
0.5
1
1.5
2
Time, sec

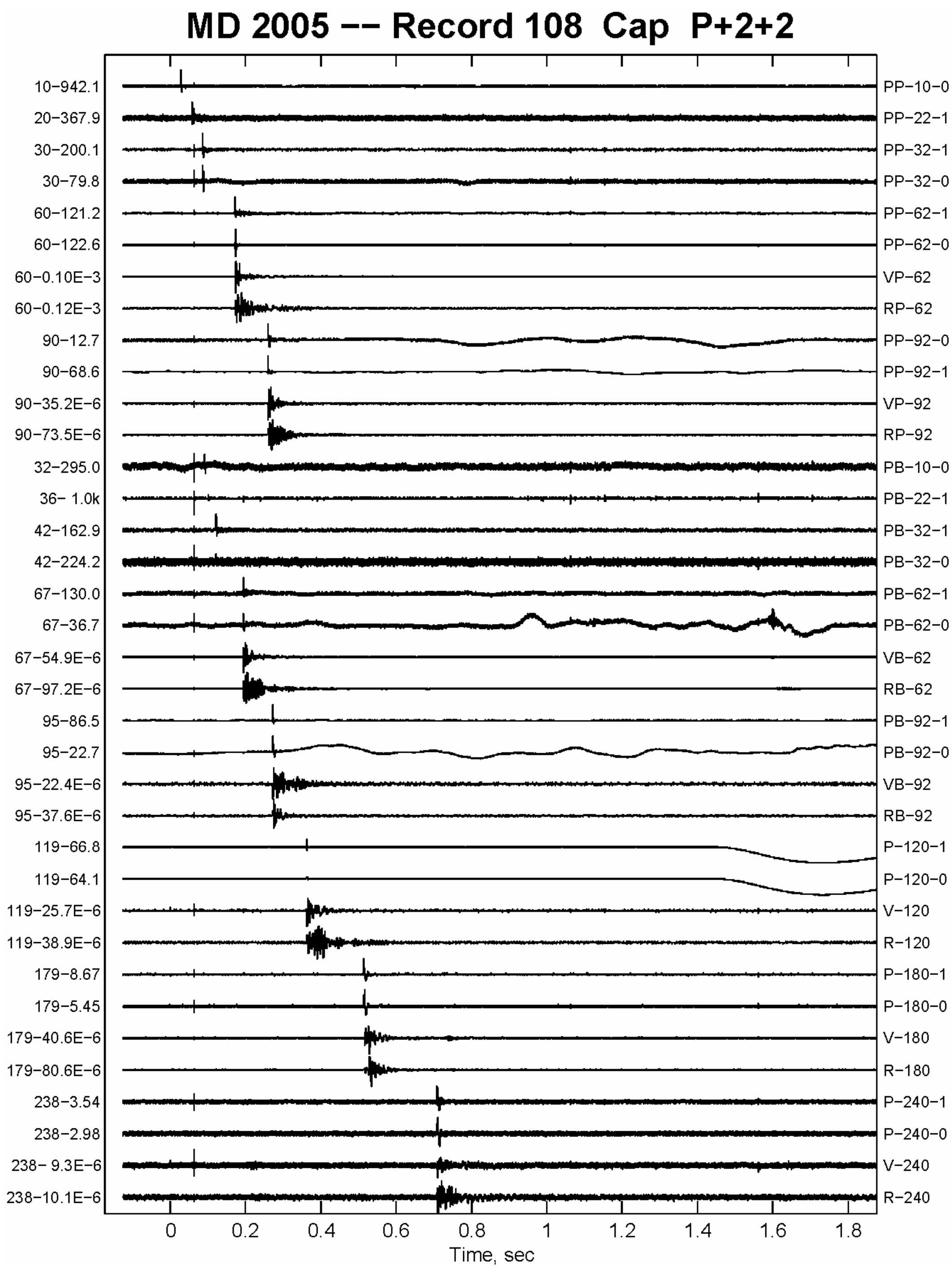

MD 2005 -- Record 66 Pistol 280 m
160−2.76
160−0.54
160− 1.4E−6
160− 4.2E−6
100−5.43
100−1.49
100−13.0E−6
100−10.1E−6
40−23.0
40−5.02
40−13.8E−6
40−19.9E−6
60−0.49
60−0.43
60− 6.4E−6
60− 3.3E−6
90−0.40
90−0.40
90− 5.1E−6
90− 3.7E−6
120−0.23
120−0.27
120− 2.4E−6
120− 2.1E−6
P−120−1
P−120−0
V−120
R−120
P−180−1
P−180−0
V−180
R−180
P−240−1
P−240−0
V−240
R−240
P−340−1
P−340−0
V−340
R−340
P−370−1
P−370−0
V−370
R−370
P−400−1
P−400−0
V−400
R−400
−0.5
0
0.5
1
1.5
2
Time, sec

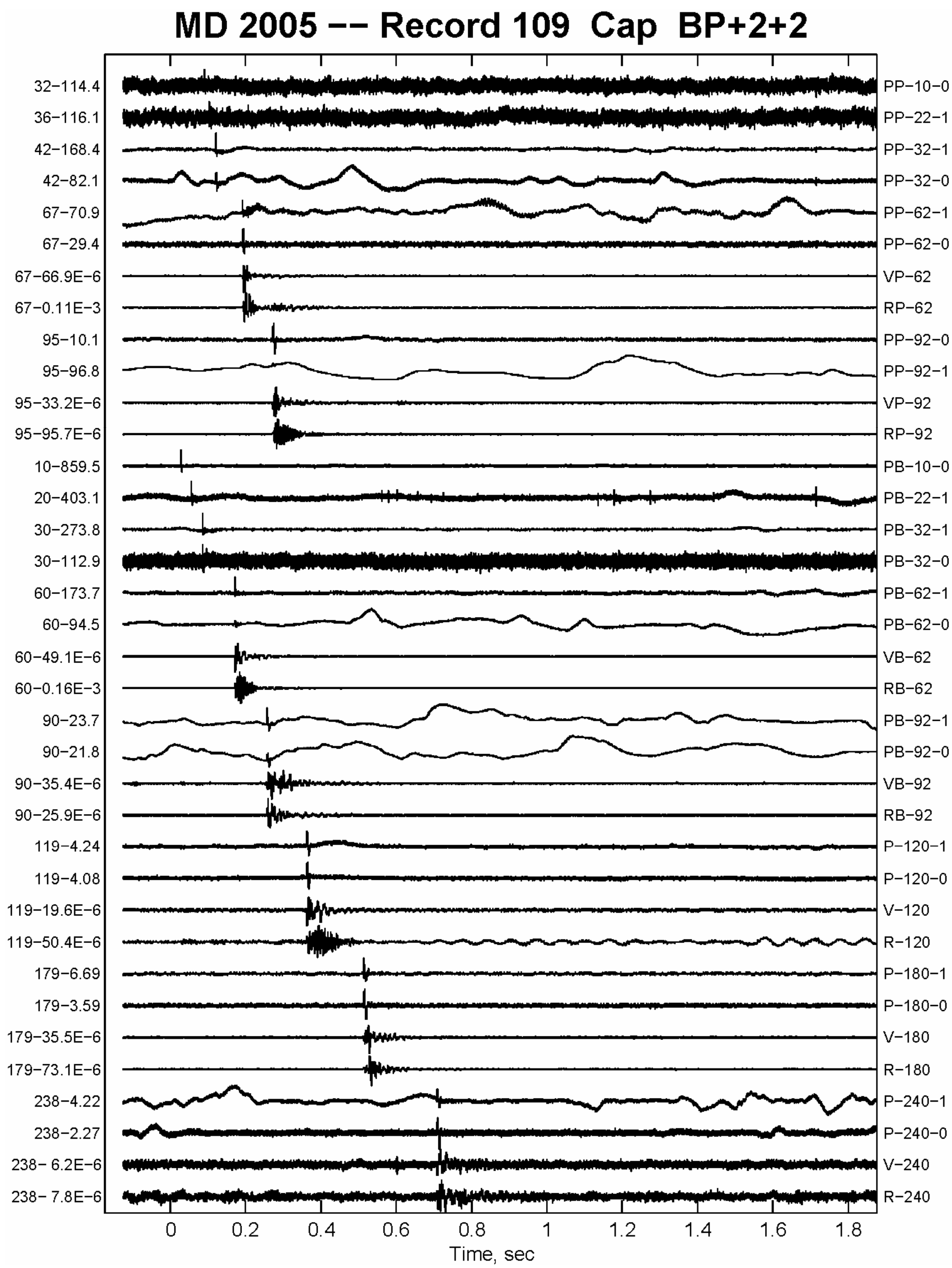

MD 2005 -- Record 67 Pistol 280 m
160−5.12
160−1.25
160− 2.6E−6
160− 9.1E−6
100−9.49
100−2.21
100−22.2E−6
100−17.4E−6
40−38.6
40−7.17
40−19.5E−6
40−30.2E−6
60−0.85
60−0.66
60− 6.9E−6
60− 6.9E−6
90−0.59
90−0.62
90− 4.7E−6
90− 6.2E−6
120−0.43
120−0.41
120− 3.6E−6
120− 2.7E−6
P−120−1
P−120−0
V−120
R−120
P−180−1
P−180−0
V−180
R−180
P−240−1
P−240−0
V−240
R−240
P−340−1
P−340−0
V−340
R−340
P−370−1
P−370−0
V−370
R−370
P−400−1
P−400−0
V−400
R−400
−0.5
0
0.5
1
1.5
2
Time, sec

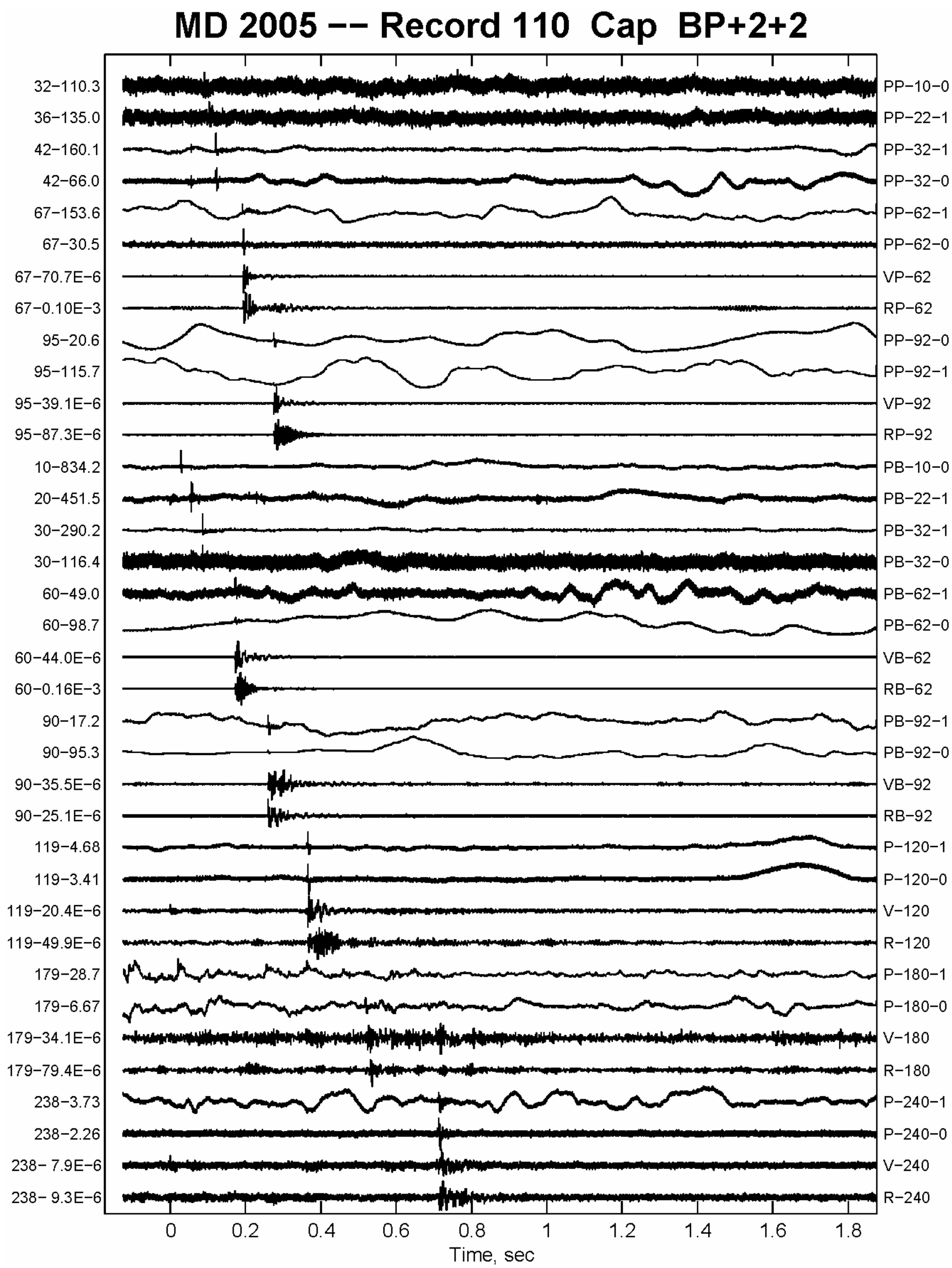
Blasting Cap Data Plots

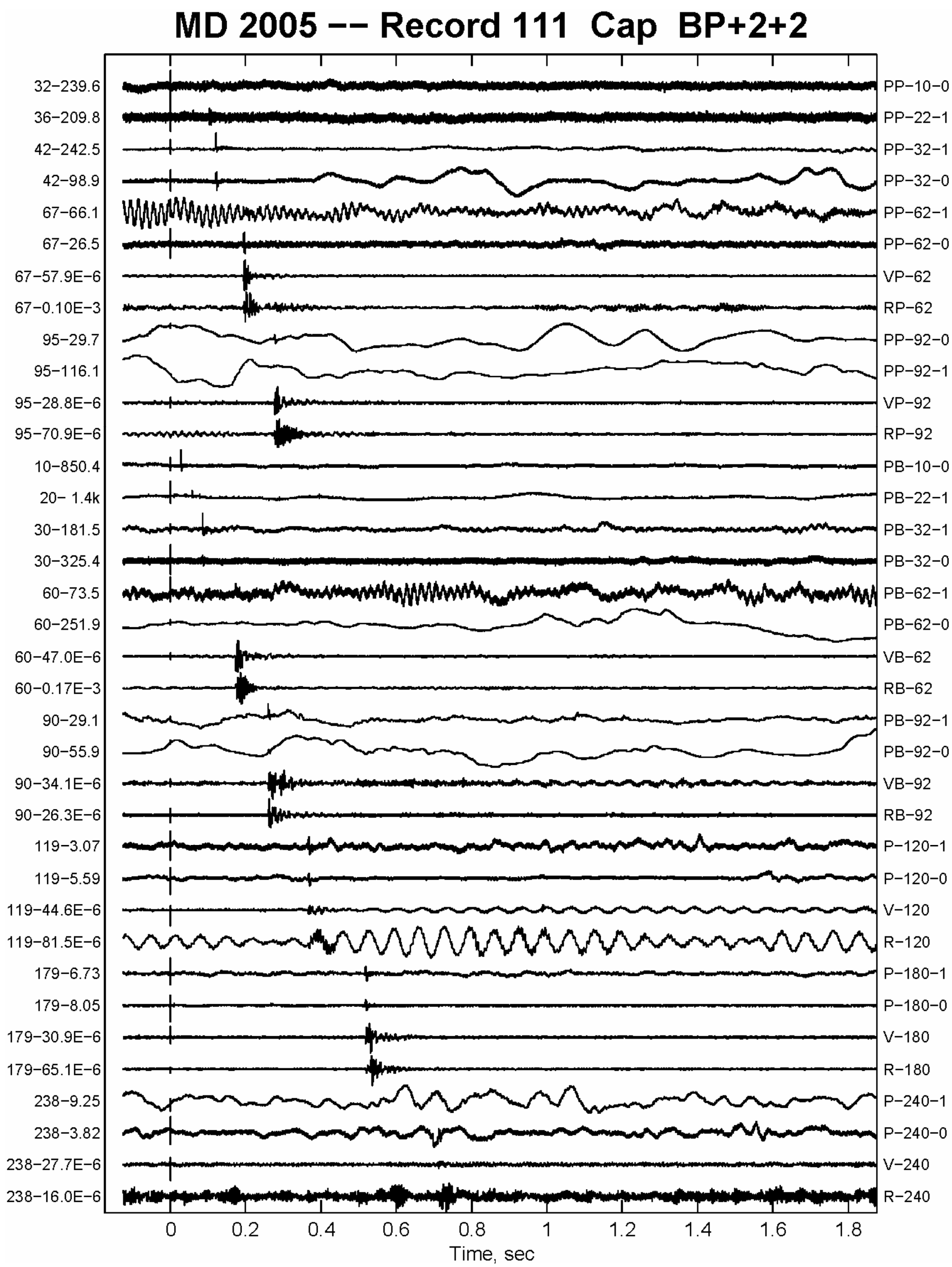



MD 2005 -- Record 107 Cap P+2+2
10- 1.0k
20-401.3
30-234.7
30-73.9
60-128.2
60-71.2
60-0.11E-3
60-0.11E-3
90-11.1
90-95.1
90-38.3E-6
90-69.9E-6
32-245.9
36-195.0
42-160.0
42-108.0
67-80.4
67-76.6
67-55.6E-6
67-90.8E-6
95-56.3
95-20.5
95-22.5E-6
95-39.5E-6
119-91.5
119-87.5
119-33.1E-6
119-41.1E-6
179-22.0
179-5.73
179-32.1E-6
179-68.9E-6
238-2.08
238-2.07
238- 5.0E-6
238- 9.0E-6
PP-10-0
PP-22-1
PP-32-1
PP-32-0
PP-62-1
PP-62-0
VP-62
RP-62
PP-92-0
PP-92-1
VP-92
RP-92
PB-10-0
PB-22-1
PB-32-1
PB-32-0
PB-62-1
PB-62-0
VB-62
RB-62
PB-92-1
PB-92-0
VB-92
RB-92
P-120-1
P-120-0
V-120
R-120
P-180-1
P-180-0
V-180
R-180
P-240-1
P-240-0
V-240
R-240
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
Time, sec


MD 2005 -- Record 108 Cap P+2+2
10−942.1
20−367.9
30−200.1
30−79.8
60−121.2
60−122.6
60−0.10E−3
60−0.12E−3
90−12.7
90−68.6
90−35.2E−6
90−73.5E−6
32−295.0
36− 1.0k
42−162.9
42−224.2
67−130.0
67−36.7
67−54.9E−6
67−97.2E−6
95−86.5
95−22.7
95−22.4E−6
95−37.6E−6
119−66.8
119−64.1
119−25.7E−6
119−38.9E−6
179−8.67
179−5.45
179−40.6E−6
179−80.6E−6
238−3.54
238−2.98
238− 9.3E−6
238−10.1E−6
PP−10−0
PP−22−1
PP−32−1
PP−32−0
PP−62−1
PP−62−0
VP−62
RP−62
PP−92−0
PP−92−1
VP−92
RP−92
PB−10−0
PB−22−1
PB−32−1
PB−32−0
PB−62−1
PB−62−0
VB−62
RB−62
PB−92−1
PB−92−0
VB−92
RB−92
P−120−1
P−120−0
V−120
R−120
P−180−1
P−180−0
V−180
R−180
P−240−1
P−240−0
V−240
R−240
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
Time, sec


MD 2005 -- Record 109 Cap BP+2+2
32−114.4
36−116.1
42−168.4
42−82.1
67−70.9
67−29.4
67−66.9E−6
67−0.11E−3
95−10.1
95−96.8
95−33.2E−6
95−95.7E−6
10−859.5
20−403.1
30−273.8
30−112.9
60−173.7
60−94.5
60−49.1E−6
60−0.16E−3
90−23.7
90−21.8
90−35.4E−6
90−25.9E−6
119−4.24
119−4.08
119−19.6E−6
119−50.4E−6
179−6.69
179−3.59
179−35.5E−6
179−73.1E−6
238−4.22
238−2.27
238− 6.2E−6
238− 7.8E−6
PP−10−0
PP−22−1
PP−32−1
PP−32−0
PP−62−1
PP−62−0
VP−62
RP−62
PP−92−0
PP−92−1
VP−92
RP−92
PB−10−0
PB−22−1
PB−32−1
PB−32−0
PB−62−1
PB−62−0
VB−62
RB−62
PB−92−1
PB−92−0
VB−92
RB−92
P−120−1
P−120−0
V−120
R−120
P−180−1
P−180−0
V−180
R−180
P−240−1
P−240−0
V−240
R−240
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
Time, sec


MD 2005 -- Record 110 Cap BP+2+2
32-110.3
36-135.0
42-160.1
42-66.0
67-153.6
67-30.5
67-70.7E-6
67-0.10E-3
95-20.6
95-115.7
95-39.1E-6
95-87.3E-6
10-834.2
20-451.5
30-290.2
30-116.4
60-49.0
60-98.7
60-44.0E-6
60-0.16E-3
90-17.2
90-95.3
90-35.5E-6
90-25.1E-6
119-4.68
119-3.41
119-20.4E-6
119-49.9E-6
179-28.7
179-6.67
179-34.1E-6
179-79.4E-6
238-3.73
238-2.26
238- 7.9E-6
238- 9.3E-6
PP-10-0
PP-22-1
PP-32-1
PP-32-0
PP-62-1
PP-62-0
VP-62
RP-62
PP-92-0
PP-92-1
VP-92
RP-92
PB-10-0
PB-22-1
PB-32-1
PB-32-0
PB-62-1
PB-62-0
VB-62
RB-62
PB-92-1
PB-92-0
VB-92
RB-92
P-120-1
P-120-0
V-120
R-120
P-180-1
P-180-0
V-180
R-180
P-240-1
P-240-0
V-240
R-240
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
Time, sec


MD 2005 -- Record 111 Cap BP+2+2
32−239.6
36−209.8
42−242.5
42−98.9
67−66.1
67−26.5
67−57.9E−6
67−0.10E−3
95−29.7
95−116.1
95−28.8E−6
95−70.9E−6
10−850.4
20− 1.4k
30−181.5
30−325.4
60−73.5
60−251.9
60−47.0E−6
60−0.17E−3
90−29.1
90−55.9
90−34.1E−6
90−26.3E−6
119−3.07
119−5.59
119−44.6E−6
119−81.5E−6
179−6.73
179−8.05
179−30.9E−6
179−65.1E−6
238−9.25
238−3.82
238−27.7E−6
238−16.0E−6
PP−10−0
PP−22−1
PP−32−1
PP−32−0
PP−62−1
PP−62−0
VP−62
RP−62
PP−92−0
PP−92−1
VP−92
RP−92
PB−10−0
PB−22−1
PB−32−1
PB−32−0
PB−62−1
PB−62−0
VB−62
RB−62
PB−92−1
PB−92−0
VB−92
RB−92
P−120−1
P−120−0
V−120
R−120
P−180−1
P−180−0
V−180
R−180
P−240−1
P−240−0
V−240
R−240
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
Time, sec

Appendix A: MATLAB Files for Blast Absorber Test

The binary data files from the NZ seismograph were analyzed and plotted using the Matlab files listed in this section. These files include:

doplotMD05.m – this file sets the record numbers to process, assigns the directory where the data files are stored (something that will have to be changed by the user), reads in the SEG2 format binary data, converts voltages to physical units, and plots the data. This program calls the following subroutines:

readnzATC.m - read the SEG-2 binary data using the field record numbers

words.m - parse ascii header lines into individual words

plotNZ48FourCol.m - plot the C-4 data in four panels OR

plotNZ48.m - to plot the pistol or blasting cap data on one panel

MD05label.m - to get sensor geometry, sensitivities, etc

The conversion to physical units is done in the plotxx.m subroutine using the information from the MD05label.m subroutine.

doplotMD05.m

```
% Fujitsu C:\aaaNZData\PlotATC05\DataReportFiles\doplotMD05.m

% Reads NZ binary records, makes 3 panel plots of data
% Calls functions
%    readnzATC.m - to read the SEG-2 binary data using the
%      field record numbers
%    words.m - to parse ascii header lines
%    plotnzmout.m - to plot the data
%      MD05label.m - to get sensor geometry, sensitivities, etc

% NZ binary record numbers;
recs = [106:111]; %Blasting caps  NOT 48 channel
recs = [48:67]; %All pistol shots
recs = [37:40 42:46 69:92 ]; %All C4 shots

% Loop to plot the files
for i = 1:length(recs);
   recnum = recs(i);
   shotnum = recs(i);
%  Construct binary data file name
   fname = sprintf(...
```

```
'C:\\DDrive\\aaaFY05BlastAbsorberTest\\BlastAbsorberCRRELBinaryDa
ta\\%s.dat',...
     num2str(recnum));

   %  Read in data from NZ binary file
   [x,npts,deltat,nchan,delayms,descalingfact,...
      stackcount,acqdate,acqtime] = readnzATC(fname,shotnum);

  %  Plot the binary data
  % plotNZ48;         %  Use for pistol shots and blasting caps
    plotNZ48FourCol;  %  For C4 shots
end %loop over files

return
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

readnzATC.m - read the SEG-2 binary data using the field record numbers

This function reads a binary seismograph file in SEG-2 format, and returns the data and header variables to the calling program. It is called by doplotMD05.m and does not call any other subroutines.

```
function [scan,samplesPerScan,samplingInterval,nbOfTraces, ...
   delaytime,descalingfact,stackcount,acqdate,acqtime] = ...
   readnzATC (filename,shotnum)

%This version uses shotnum to select correct STACK index in
header
%  Lines 158 below

%  This fcn reads a binary seismograph file in SEG-2 format, and
returns the
%  data in "scan" variable above.
%  This code written by Don Albert, CRREL, and based on code
"SEG2LOAD" written
%    by Pièce PY to read a radar file in modified SEG-2 format.
Some of Piece's
%    original code is still here in this file.
%  Calls fcn words.m

%  To read one NZ file directly:
%fname =
'10077.dat';[x,npts,deltat,nchan,npts2,delayms,descalingfact,acqd
ate,acqtime] = readnz(fname);

% READNZ  - For Geometrics NZ seismograph

% READNZ   Modified by D Albert to read standard SEG-2 format
% SEG2LOAD Read a SEG-2 (standard SEG-2 format of the Society of
Exploration Geophysicist)
%          file from disk.
%
[scan,samplesPerScan,samplingInterval,shaftInterval,timerFrequenc
y]=
%              =seg2load ('filename') reads
```

```
%           the file 'filename' and returns the image scan [m,n]
containing
%               n A-Scan of m samples.
%           If no extension is given for the filename, the exten-
sion '.sg2' is assumed.
%           samplesPerScan   contains the number of samples per A-
scan
%           shaftInterval    contains the distance between shaft
encoder triggers in meter
%           samplingInterval contains the time between 2 samples
in pico-seconds
%           timerFrequency   contains the frequency of A-scan sam-
pling in Hz
%
%           Pièce PY 24/07/1996
%           LAMI - DeTeC Demining Technology Center
%           Swiss Federal Institute of Technology (EPFL) -
Lausanne, Switzerland

% check argument and filename
  if (nargin==0)
    error ('readseg2 requires at least a filename as an argument
!');
  end;
  if (isstr (filename)~=1)
    error ('Argument is not a filename !');
  end;
  if (isempty (findstr (filename,'.'))==1)
    filename =[filename,'.sg2'];
  end;
  fid=fopen (filename,'rb','ieee-le');
  if (fid ==-1)
    error (['Error opening ',filename,' for input !']);
  end;

% check for SEG-2 file type
% first 2 bytes equal '3a55h' (14933) for PC/Windows
  fileType=fread (fid,1,'short');
  if (fileType ~= 14933)
    fclose (fid);
    error ('Not a SEG-2 file !');
 end;

 %  Open a log file to keep track of files that were read
 fid2 = fopen('readnzlog.m','a');
 fprintf(fid2,' \n');

  samplesPerScan  =0;
  shaftInterval   =0;
  samplingInterval=0;
  timerFrequency  =0;

% read File Descriptor Block

  revNumber          = fread (fid,1,'short');
  sizeOfTracePointer = fread (fid,1,'ushort');
  nbOfTraces         = fread (fid,1,'ushort');
```

```
    sizeOfST            = fread (fid,1,'uchar');
    firstST             = fread (fid,1,'char');
    secondST            = fread (fid,1,'char');
    sizeOfLT            = fread (fid,1,'uchar');
    firstLT             = fread (fid,1,'char');
    secondLT            = fread (fid,1,'char');
    reserved            = fread (fid,18,'uchar');
    tracePointers       = fread (fid,nbOfTraces,'ulong');

  % read free strings

    fseek (fid,32+sizeOfTracePointer,'bof');
    offset = fread (fid,1,'ushort');

  %  File descriptor block
    while (offset > 0)
       freeString = setstr (fread (fid,offset-2,'char'))'; %
       %Decode file descriptor block
       if (findstr (freeString,'ACQUISITION_DATE') > 0)
            acqdate =  (freeString ...
               (length ('ACQUISITION_DATE '):length (freeString)));
         end
         if (findstr (freeString,'ACQUISITION_TIME') > 0)
            acqtime =  (freeString ...
               (length ('ACQUISITION_TIME '):length (freeString)));
         end
      offset = fread (fid,1,'ushort');
    end;

    %  acqdate, acqtime, offset
  % read traces

  %find number of samples per trace
  %  First trace descriptor block
      fseek (fid,tracePointers (1),'bof');
      traceId     = fread (fid,1,'ushort');
      sizeOfBlock = fread (fid,1,'ushort');
      sizeOfData  = fread (fid,1,'ulong');
      nbOfSamples = fread (fid,1,'ulong');
      samplesPerScan = nbOfSamples;
      % traceId,sizeOfBlock,sizeOfData,nbOfSamples,samplesPerScan

      dataCode    = fread (fid,1,'uchar');
      reserved    = fread (fid,19,'uchar');
      offset = fread (fid,1,'ushort');
      while (offset > 0)
         freeString = setstr (fread (fid,offset-2,'char'))';
         if (findstr (freeString,'SAMPLE_INTERVAL') > 0)
            samplingInterval = str2num (freeString ...
               (length ('SAMPLE_INTERVAL '):length (freeString)));
         end
         if (findstr (freeString,'DELAY') > 0)
            delaytime = 1000*str2num (freeString ...
               (length ('DELAY '):length (freeString)));
         end
         if (findstr (freeString,'DESCALING_FACTOR') > 0)
            descalingfactor = str2num (freeString ...
```

```
             (length ('DESCALING_FACTOR '):length (freeString)));
       end
       offset = fread (fid,1,'ushort');
    end;
    % samplingInterval, delaytime, descalingfactor

 %Write file descriptor to log file
    fprintf(fid2,'%s %s %s %g %g %g %g
\n',filename,acqdate,acqtime,nbOfSamples,...
       samplingInterval,delaytime,descalingfactor);

 scan = zeros (nbOfSamples,nbOfTraces);
 for i=1:nbOfTraces,
    fseek (fid,tracePointers (i),'bof');
    traceId     = fread (fid,1,'ushort');
    sizeOfBlock = fread (fid,1,'ushort');
    sizeOfData  = fread (fid,1,'ulong');
    nbOfSamples = fread (fid,1,'ulong');
    dataCode    = fread (fid,1,'uchar');
    reserved    = fread (fid,19,'uchar');
    %  Trace descriptor blocks
    %Reads all at once
    freeString = setstr (fread (fid,sizeOfBlock-32,'char'))';
    w = words(freeString);
    %  Remove percent below to print trace header to screen for
    %  adjustment
    %if(i==1);w,end
    descalingfact(i) = str2num(w(7,1:14));
    if(shotnum < 10 | shotnum > 99)
     stackcount(i) = str2num(w(27,1:2)); %files 1 - 9.dat and
>=100.dat
    else
         stackcount(i) = str2num(w(28,1:2)); %files >=10.dat and
<=99.dat
    end

%    w = words(freeString);
   %MOUT data
   %descalingfact(i) = str2num(w(4,1:14));
   %stackcount(i) = str2num(w(18,1:2));
%    descalingfact(i) = str2num(w(7,1:14));
    %stackcount(i) = str2num(w(26,1:2));
%    stackcount(i) = str2num(w(27,1:2));
    % read the data here
    scan (1:nbOfSamples,i)  = fread (fid,nbOfSamples,'float32');
  end;

      fclose (fid); %close data file

  return

%  w =

%  CHANNEL_NUMBER
% 48  DELAY
% -0.050 ! DESCALING_FACTOR
% 2.697400E-003  FIXED_GAIN
```

```
% 24
% DB
%  LINE_ID
% 0  LOW_CUT_FILTER
% 0
% 0  NOTCH_FREQUENCY
% 0  RAW_RECORD
%   RECEIVER_LOCATION
% 570.00  SAMPLE_INTERVAL
% 0.000125  SKEW
% -0.0000625  SOURCE_LOCATION
% 0.00
%  STACK
% 1  NOTE
% DISPLAY_SCALE
% 67
%%SKEW = ???

%  MN02:
%  ALIAS_FILTER
%3333.33
%0   AMPLITUDE_RECOVERY
%NONE   CHANNEL_NUMBER
%1   DELAY
%-0.050 ! DESCALING_FACTOR
%2.697400E-003 - DIGITAL_HIGH_CUT_FILTER
%0
%0   DIGITAL_LOW_CUT_FILTER
%0
%0   FIXED_GAIN
%24
%DB
% LINE_ID
%0   LOW_CUT_FILTER
%0
%0   NOTCH_FREQUENCY
%0   RAW_RECORD
%D:\4000\35.dat   RECEIVER_LOCATION
%510.00   SAMPLE_INTERVAL
%0.000125   SHOT_SEQUENCE_NUMBER
%35   SKEW
%-0.0000625   SOURCE_LOCATION
%0.00
% STACK
%1  NOTE
%DISPLAY_SCALE
%63
```

words.m - parse ascii header lines into individual words

This function separates a long string of text into separate words. It does not call any other subroutines. This function is from the Matlab manual.

```
function all_words = words(input_string)
%  filename:  words.m
```

```
%  Separates words in a long string
%  Individual words are then in all_words(9,:)
%  From the book, Using Matlab, p. 11-12

remainder = input_string;
all_words = '';

while (any(remainder))
   [chopped,remainder] = strtok(remainder);
   all_words = strvcat(all_words,chopped);
end

return
```

plotNZ48FourCol.m - plot the C-4 data in four panels

This code plots 48 channels of data in four separate panels on a sheet of landscape oriented paper. Because of intermittent interference with the blasting electrical pulse, the program mutes or zeros the first 20 ms of data on channels 1 – 24. In addition, the first 226 ms of data for channel 15 are muted since that channel suffered from additional interference.

This code calls MD05label.m to get the experimental information including source type and location, receiver location, receiver sensitivities, etc.

```
%  PlotNZ48FourCol.m - 48 channels in 4 columns
%  Includes TB muting for channels 1-24

% Need to set file name and read in data first
%   using readnz sbr
% Calls sbrs
%   MD05label.m - supplies the details of the expt
%      including sensitivity, coords of each channel etc.
% Don Albert   Donald.G.Albert@erdc.usace.army.mil
%  USA ERDC-CRREL, 72 Lyme Road, Hanover, NH 03755

iprint=1; % to print and delete plot
iprint = 0; %skip printing

nchan = 48;

srate = 1/  deltat; %number of samples per second
t = (1:npts)*deltat + delayms/1000; %
tend = npts;
tstart2=1;tend2=tend;t2=t;
tstartpanel1 = 0.0;
tstartpanel1 = delayms/1000;  %
tendpanel1 = tstartpanel1 + t(tend);

%  Default time window (entire record)
tt2 = 0.0;  tt3 = t(tend);
tt2 = tstartpanel1; tt3 = t(tend); %
```

```
tstart2 = floor(tt2/deltat);tend2 = round(tt3/deltat);
if(tstart2 <= 1); tstart2 = 1; end
tstartpanel1 = tt2;tendpanel1 = tt3;

%apply TB mute to the close-in pressure sensors and VB-62 (Chan
18)
imutechannels = [3 4 7:12 15 16 18:24];
%  Apply TB mute to the close-in channels (geos infrequently need
it)
imutechannels = [1:24];
tmute = 0.02;
indexmute = round(tmute/deltat)-delayms/(1000*deltat);
x(1:indexmute,imutechannels) = 0;
%  PB-92-0 needs add'l muting
tmute = 0.226;
indexmute = round(tmute/deltat)-delayms/(1000*deltat);
x(1:indexmute,15) = 0;

xx = [];
for i = 1:nchan;xmax(i)=max(abs(x(:,i))); end
for i = 1:nchan;xmax(i)=max(abs(x(tstart2:tend2,i))); end
if(xmax(i) == 0); xmax(i) = 1; end

%  Get geometry, etc for this experiment
[sensor,sensortype,rtype,sensorx,sensory,sensorz,...
          srcloc,sourcetype,stype,srcx,srcy,srcz,sourcesize,...
          engfact,dist,sensor2,source2] = MD05label
(x,shotnum,nchan);

if(shotnum>=112 & shotnum <=117); nchan = 36; end
if(shotnum>=118 ); nchan = 24; end

%  Conversion factor from voltage to physical units (Pa or m/s)
%xgain = descalingfact./(stackcount.*engfact); %recorder units to
eng units
for i = 1:nchan;
   if(stackcount(i)==0); stackcount(i)=1; end
   %recorder units to eng units
   xgain(i) = descalingfact(i)./(stackcount(i).*engfact(i));
   xx(:,i) = x(:,i) * xgain(i);
   %xxmax(i) = max(abs(xx)); %abs max for plotting - entire trace
   xxmax(i) = max(abs(xx(tstart2:tend2,i))); %abs max for plot-
ting
end

[aa bb] = max(xx); %set plot windows because manual TB
[cc dd] = min(xx); %for output file
tmax1 =  delayms/1000 + (bb(1) )/srate; %P-1-0 times in seconds
tmax21 = delayms/1000 + (bb(21))/srate; %P-100-0
tstart1=  floor(tmax1 *10)/10;
tstart21= floor(tmax21*10)/10;
textmax=max(max(t))+max(max(t))/30;
textmin=min(t)-max(max(t))/30;

nametext = ['NZ Data - 1 panel'];  %---------------FIGURE  - 4
Panel
f1 = figure('Name',nametext);
```

```
set(gcf,'Units','inches','PaperUnits','inches');

iplot = [37:48 25:36 13:24 1:12   ];
% Switch channels close to source for bare ground shots:
if (srcloc(1)=='B');
  iiplot = [37:48 25:36 1:12 13:24   ];
end
%  Use same channel order for all shots
iiplot = [37:48 25:36 1:12 13:24   ];

subplot(1,4,1); %%%%%%%%%%%%%%%%%%%%%%%%%%Panel 1  %%%%
tstartpanel1=0.0; tendpanel1=0.4;
% First 12 channels
iplot=iiplot(37:48);
nplot = length(iplot);

% Set axis params here; depends on nplot  -  t2
yshift = (1:nplot)*2 - 2;
%ax = [t2(1) max(t2) -1 2*nplot];
ax = [tstartpanel1-0.05 tendpanel1 -1 2*nplot];
%ax = [1 3 -1 2*nplot];
axis(ax);
ax1 = gca; set(ax1,'YTick',[]); set(ax1,'Box','on');
xlabel('Time, sec')

%  plot data and label
hold on;
for i=1:nplot
  plot(t,(xx(1:length(t),iplot(i))/xxmax(iplot(i)))
+yshift(i),'k');
  leftlabel = sprintf('%g',round(dist(iplot(i))));
  distlabel = sprintf('%g',round(dist(iplot(i))));
  str1 = sensor(iplot(i),:);
  str2 = sprintf('%7.2e',(xxmax(iplot(i))));
  if (xxmax(iplot(i))) < 0.0001
     str2=sprintf('%4.1fE-6',(1E6*xxmax(iplot(i))));
   elseif (xxmax(iplot(i))) < 0.001
     str2=sprintf('%4.2fE-3',(1E3*xxmax(iplot(i))));
   elseif (xxmax(iplot(i))) < 0.01
     str2=sprintf('%4.2fE-3',(1E3*xxmax(iplot(i))));
   elseif (xxmax(iplot(i))) < 0.1
     str2=sprintf('%4.1fE-3',(1E3*xxmax(iplot(i))));
   elseif (xxmax(iplot(i))) < 10.0
     str2=sprintf('%4.2f',(xxmax(iplot(i))));
   elseif (xxmax(iplot(i))) < 100.0
     str2=sprintf('%4.1f',(xxmax(iplot(i))));
   elseif (xxmax(iplot(i))) > 1000.0
     str2=sprintf('%4.1fk',( xxmax(iplot(i))/1000 ));
   else
     str2=sprintf('%4.1f',(xxmax(iplot(i))));
  end  %text loop
  str3 = char(str1);
  str4 = [str3 '-' str2]; %Concat on one line
  str4 = [str3 ]; %Concat on one line
  str5 = cellstr(str4);
  leftlabel02 = [leftlabel '-' str2];
  str4 = char(str2 , str3);
```

```
  str5 = cellstr(str4);
  text(tstartpanel1-0.05-0.02,[yshift(i)],str5,'FontSize',8,...
      'HorizontalAlignment','right');
  text(tendpanel1-0.02,[yshift(i)+0.3],distlabel,'FontSize',8,...
      'HorizontalAlignment','right');

end

subplot(1,4,2); %%%%%%%%%%%%%%%%%%%%%%%%%%Panel 2 %%%
tstartpanel1=0.0; tendpanel1=0.4;
% First 12 channels
iplot=iiplot(25:36);
nplot = length(iplot);
% Set axis params here; depends on nplot  -  t2
yshift = (1:nplot)*2 - 2;
ax = [tstartpanel1-0.05 tendpanel1 -1 2*nplot];
axis(ax);
ax1 = gca; set(ax1,'YTick',[]); set(ax1,'Box','on');
xlabel('Time, sec')
%  plot data and label
hold on;
for i=1:nplot
  plot(t,(xx(1:length(t),iplot(i))/xxmax(iplot(i)))
+yshift(i),'k');
  leftlabel = sprintf('%g',round(dist(iplot(i))));
  distlabel = sprintf('%g',round(dist(iplot(i))));
  str1 = sensor(iplot(i),:);
  str2 = sprintf('%7.2e',(xxmax(iplot(i))));
  if (xxmax(iplot(i))) < 0.0001
     str2=sprintf('%4.1fE-6',(1E6*xxmax(iplot(i))));
   elseif (xxmax(iplot(i))) < 0.001
     str2=sprintf('%4.2fE-3',(1E3*xxmax(iplot(i))));
   elseif (xxmax(iplot(i))) < 0.01
     str2=sprintf('%4.2fE-3',(1E3*xxmax(iplot(i))));
   elseif (xxmax(iplot(i))) < 0.1
     str2=sprintf('%4.1fE-3',(1E3*xxmax(iplot(i))));
   elseif (xxmax(iplot(i))) < 10.0
     str2=sprintf('%4.2f',(xxmax(iplot(i))));
   elseif (xxmax(iplot(i))) < 100.0
     str2=sprintf('%4.1f',(xxmax(iplot(i))));
   elseif (xxmax(iplot(i))) > 1000.0
     str2=sprintf('%4.1fk',( xxmax(iplot(i))/1000 ));
   else
     str2=sprintf('%4.1f',(xxmax(iplot(i))));
  end  %text loop
  str3 = char(str1);
  str4 = char(str2 , str3);
  str5 = cellstr(str4);
  text(tstartpanel1-0.05-0.02,[yshift(i)],str5,'FontSize',8,...
      'HorizontalAlignment','right');
  text(tendpanel1-0.02,[yshift(i)+0.3],distlabel,'FontSize',8,...
      'HorizontalAlignment','right');

end %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

subplot(1,4,3); %%%%%%%%%%%%%%%%%%%%%%%%%%Panel 3 %%%%%%%%
tstartpanel1=0.3; tendpanel1=0.9;
```

```
% 120-240 m
iplot=iiplot(13:24);
nplot = length(iplot);
% Set axis params here; depends on nplot  -  t2
yshift = (1:nplot)*2 - 2;
ax = [tstartpanel1-0.05 tendpanel1 -1 2*nplot];
axis(ax);
ax1 = gca; set(ax1,'YTick',[]); set(ax1,'Box','on');
xlabel('Time, sec')
%  plot data and label
hold on;
for i=1:nplot
  plot(t,(xx(1:length(t),iplot(i))/xxmax(iplot(i)))
+yshift(i),'k');
  leftlabel = sprintf('%g',round(dist(iplot(i))));
  distlabel = sprintf('%g',round(dist(iplot(i))));
  str1 = sensor(iplot(i),:);
  str2 = sprintf('%7.2e',(xxmax(iplot(i))));
  if (xxmax(iplot(i))) < 0.0001
     str2=sprintf('%4.1fE-6',(1E6*xxmax(iplot(i))));
   elseif (xxmax(iplot(i))) < 0.001
     str2=sprintf('%4.2fE-3',(1E3*xxmax(iplot(i))));
   elseif (xxmax(iplot(i))) < 0.01
     str2=sprintf('%4.2fE-3',(1E3*xxmax(iplot(i))));
   elseif (xxmax(iplot(i))) < 0.1
     str2=sprintf('%4.1fE-3',(1E3*xxmax(iplot(i))));
   elseif (xxmax(iplot(i))) < 10.0
     str2=sprintf('%4.2f',(xxmax(iplot(i))));
   elseif (xxmax(iplot(i))) < 100.0
     str2=sprintf('%4.1f',(xxmax(iplot(i))));
   elseif (xxmax(iplot(i))) > 1000.0
     str2=sprintf('%4.1fk',( xxmax(iplot(i))/1000 ));
   else
     str2=sprintf('%4.1f',(xxmax(iplot(i))));
  end  %text loop
  str3 = char(str1);
  str4 = char(str2 , str3);
  str5 = cellstr(str4);
  text(tstartpanel1-0.05-0.02,[yshift(i)],str5,'FontSize',8,...
      'HorizontalAlignment','right');
  text(tendpanel1-0.02,[yshift(i)+0.3],distlabel,'FontSize',8,...
      'HorizontalAlignment','right');

end %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

subplot(1,4,4); %%%%%%%%%%%%%%%%%%%%%%%%%%Panel 4 %%%%%%%%
tstartpanel1=0.9; tendpanel1=1.4;
% 340-400 m
iplot=iiplot(1:12);
nplot = length(iplot);
% Set axis params here; depends on nplot  -  t2
yshift = (1:nplot)*2 - 2;
ax = [tstartpanel1-0.05 tendpanel1 -1 2*nplot];
axis(ax);
ax1 = gca; set(ax1,'YTick',[]); set(ax1,'Box','on');
xlabel('Time, sec')
%  plot data and label
```

```
hold on;
for i=1:nplot
  plot(t,(xx(1:length(t),iplot(i))/xxmax(iplot(i)))
+yshift(i),'k');
  leftlabel = sprintf('%g',round(dist(iplot(i))));
  distlabel = sprintf('%g',round(dist(iplot(i))));
  str1 = sensor(iplot(i),:);
  str2 = sprintf('%7.2e',(xxmax(iplot(i))));
  if (xxmax(iplot(i))) < 0.0001
     str2=sprintf('%4.1fE-6',(1E6*xxmax(iplot(i))));
   elseif (xxmax(iplot(i))) < 0.001
     str2=sprintf('%4.2fE-3',(1E3*xxmax(iplot(i))));
   elseif (xxmax(iplot(i))) < 0.01
     str2=sprintf('%4.2fE-3',(1E3*xxmax(iplot(i))));
   elseif (xxmax(iplot(i))) < 0.1
     str2=sprintf('%4.1fE-3',(1E3*xxmax(iplot(i))));
   elseif (xxmax(iplot(i))) < 10.0
     str2=sprintf('%4.2f',(xxmax(iplot(i))));
   elseif (xxmax(iplot(i))) < 100.0
     str2=sprintf('%4.1f',(xxmax(iplot(i))));
   elseif (xxmax(iplot(i))) > 1000.0
     str2=sprintf('%4.1fk',( xxmax(iplot(i))/1000 ));
   else
     str2=sprintf('%4.1f',(xxmax(iplot(i))));
  end  %text loop
  str3 = char(str1);
  str4 = char(str2 , str3);
  str5 = cellstr(str4);
  text(tstartpanel1-0.05-0.02,[yshift(i)],str5,'FontSize',8,...
      'HorizontalAlignment','right');
  text(tendpanel1-0.02,[yshift(i)+0.3],distlabel,'FontSize',8,...
      'HorizontalAlignment','right');
end %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

if(stype==1);
   plottitle = sprintf('MD 2005 -- Record %g  Shot #%s  %s  ',...
     shotnum,source2,srcloc);
else
   plottitle = sprintf('MD 2005 -- Record %g  %s  %s  ',...
     shotnum,source2,srcloc);
end
subplot(1,4,2); hold on;
title(plottitle,'FontSize',18,'FontWeight','Bold');
set(gcf,'PaperUnits','inches');
%set(gcf,'PaperPosition',[0.5,0.5,7,10]);
%set(gcf,'PaperOrientation','portrait');
set(gcf,'PaperPosition',[0.5,0.5,10,7]);
set(gcf,'PaperOrientation','landscape');

if(iprint==1); print -dljetplus; delete(f1); end

return %----------------------------------------------------------------
```

plotNZ48.m - to plot the pistol or blasting cap data on one panel

This code plots 48 channels of data in a single panel on a sheet of portrait oriented paper. This code does not mute any data.

This code calls MD05label.m to get the experimental information including source type and location, receiver location, receiver sensitivities, etc.

```
%  PlotNZ48.m - 48 channels

% Need to set file name and read in data first
%   using readnz sbr
% Calls sbrs
%   MD05label.m - supplies the details of the expt
%      including sensitivity, coords of each channel etc.
% Don Albert   Donald.G.Albert@erdc.usace.army.mil
%  USA ERDC-CRREL, 72 Lyme Road, Hanover, NH 03755

iprint=1; % to print and delete plot
iprint = 0; %skip printing

nchan = 48;
if(shotnum>=107 & shotnum <=117); nchan = 36; end
if(shotnum>=118 ); nchan = 24; end

srate = 1/  deltat; %number of samples per second
t = (1:npts)*deltat + delayms/1000; %
tend = npts;
tstart2=1;tend2=tend;t2=t;
tstartpanel1 = 0.0;
tstartpanel1 = delayms/1000;  %
tendpanel1 = tstartpanel1 + t(tend);

%  Default time window (entire record)
tt2 = 0.0;  tt3 = t(tend);
tt2 = tstartpanel1; tt3 = t(tend); %

% Time windows for individual records
%if(recnum==235); tt2 = 0.6; tt3 = 1.4;
%elseif(recnum==231); tt2 = 2.0; tt3 = 8.0;
%%elseif(recnum==231); tt2 = 1.19; tt3 = 1.21; %Lightning strike?
%end

tstart2 = floor(tt2/deltat);tend2 = round(tt3/deltat);
if(tstart2 <= 1); tstart2 = 1; end
tstartpanel1 = tt2;tendpanel1 = tt3;

%ttstart = 0.0;ttend = 2.0; %time window in seconds for plot

%tend = length(x(:,1)); %Plot all of data = default
%t = delayms/1000 + (1:tend)/srate;
%tstart2=1;tend2=tend;t2=t;


xx = [];
for i = 1:nchan;xmax(i)=max(abs(x(:,i))); end
for i = 1:nchan;xmax(i)=max(abs(x(tstart2:tend2,i))); end
```

```
if(xmax(i) == 0); xmax(i) = 1; end

%Now set in doplotnz.m shotnum = str2num(fname(length(fname)-
6:length(fname)-4));

%  Get geometry, etc for this experiment
[sensor,sensortype,rtype,sensorx,sensory,sensorz,...
          srcloc,sourcetype,stype,srcx,srcy,srcz,sourcesize,...
          engfact,dist,sensor2,source2] = MD05label
(x,shotnum,nchan);

if(shotnum>=112 & shotnum <=117); nchan = 36; end
if(shotnum>=118 ); nchan = 24; end

%if(stype==9); nchan=24; end % Pistol shots, B&K mikes only

%  Conversion factor from voltage to physical units (Pa or m/s)
%xgain = descalingfact./(stackcount.*engfact); %recorder units to
eng units
for i = 1:nchan;
   if(stackcount(i)==0); stackcount(i)=1; end
   % Convert recorder units to eng units
   xgain(i) = descalingfact(i)./(stackcount(i).*engfact(i));
   xx(:,i) = x(:,i) * xgain(i);
   % xxmax(i) = max(abs(xx)); %abs max for plotting - entire
trace
   xxmax(i) = max(abs(xx(tstart2:tend2,i))); %abs max for plot-
ting
end

[aa bb] = max(xx); %set plot windows because manual TB
[cc dd] = min(xx); %for output file
tmax1 =  delayms/1000 + (bb(1) )/srate; %P-1-0 times in seconds
tmax21 = delayms/1000 + (bb(21))/srate; %P-100-0
tstart1=  floor(tmax1 *10)/10;
tstart21= floor(tmax21*10)/10;

%tstartpanel1 = 0.0;
%tendpanel1 = tstartpanel1 + t(tend);

textmax=max(max(t))+max(max(t))/30;
textmin=min(t)-max(max(t))/30;

nametext = ['NZ Data - 1 panel'];  %------------FIGURE  - 1 Panel
f1 = figure('Name',nametext);
set(gcf,'Units','inches','PaperUnits','inches');

% Pressure sensors - Channels 1-12
% iplot=12:-1:1; %Channels 1-12
%iplot = [12:-1:1 16 15 14 13 29:36 24:-1:17 25:28 ];
iplot = [24:-1:1 ];
iplot = [13:24 12:-1:1];
iplot = [12:-1:1  24:-1:13  36:-1:25  48:-1:37 ];
iplot = [48:-1:37 36:-1:25 24:-1:13 12:-1:1    ];
iplot = [37:48 25:36 13:24 1:12   ];
% Switch channels close to source for bare ground shots:
if (srcloc(1)=='B');
```

```
  iplot = [37:48 25:36 1:12 13:24   ];
end

if(stype==9); iplot = [37:48 25:36  ]; end % Pistol shots, B&K
mikes only
if(nchan==36); iplot = [25:36  13:24 1:12  ]; end % Pistol shots,
B&K mikes only
if(nchan==24); iplot = [ 13:24 1:12  ]; end % Pistol shots, B&K
mikes only

nplot = length(iplot);

% Set axis params here; depends on nplot  -  t2
yshift = (1:nplot)*2 - 2;
%ax = [t2(1) max(t2) -1 2*nplot];
ax = [tstartpanel1-0.05 tendpanel1 -1 2*nplot];
%ax = [1 3 -1 2*nplot];
axis(ax);
ax1 = gca; set(ax1,'YTick',[]); set(ax1,'Box','on');
xlabel('Time, sec')

%  Write trace data to text file
fid7 = fopen('Plot48Traces.m','a');
fprintf(fid7,'MD 2005 -- Record %g  %s  %s
\n',shotnum,source2,srcloc);
fprintf(fid7,...
' i,ii    engfact    xgain      xxmax      mV = xxmax/engfact
\n');
for i=nplot:-1:1
  ii = iplot(i);
  fprintf(fid7,'%2g %2g %10.2e %10.2e %10.2e %10.2e %s %s \n',...
    i,ii, engfact(ii), xgain(ii), xxmax(ii),
xxmax(ii)/engfact(ii),...
    sensor(ii,:),sensor2(ii,1:16) );
 %    [iplot; engfact(iplot); xxmax(iplot)]'
end
fprintf(fid7,' \n');
fprintf(fid7,' \n');
fclose(fid7);

%  plot data and label
hold on;
for i=1:nplot
  plot(t,(xx(1:length(t),iplot(i))/xxmax(iplot(i)))
+yshift(i),'k');
  leftlabel = sprintf('%g',round(dist(iplot(i))));
  str1 = sensor(iplot(i),:);
  str2 = sprintf('%7.2e',(xxmax(iplot(i))));
  if (xxmax(iplot(i))) < 0.0001
     str2=sprintf('%4.1fE-6',(1E6*xxmax(iplot(i))));
   elseif (xxmax(iplot(i))) < 0.001
     str2=sprintf('%4.2fE-3',(1E3*xxmax(iplot(i))));
   elseif (xxmax(iplot(i))) < 0.01
     str2=sprintf('%4.2fE-3',(1E3*xxmax(iplot(i))));
   elseif (xxmax(iplot(i))) < 0.1
     str2=sprintf('%4.1fE-3',(1E3*xxmax(iplot(i))));
   elseif (xxmax(iplot(i))) < 10.0
```

```
     str2=sprintf('%4.2f',(xxmax(iplot(i))));
   elseif (xxmax(iplot(i))) < 100.0
     str2=sprintf('%4.1f',(xxmax(iplot(i))));
   elseif (xxmax(iplot(i))) > 1000.0
     str2=sprintf('%4.1fk',( xxmax(iplot(i))/1000 ));
   else
     str2=sprintf('%4.1f',(xxmax(iplot(i))));
  end  %text loop
  %skip all scaling, just write peak
  %   str2=sprintf('%4.1e',(xxmax(iplot(i))));
  str3 = char(str1);
  %str4 = char(str3 , str2);%Two lines
  str4 = [str3 '-' str2]; %Concat on one line
  str4 = [str3 ]; %Concat on one line
  str5 = cellstr(str4);
  text(tendpanel1+0.02,[yshift(i)],str5,'FontSize',8,...
      'HorizontalAlignment','left');
  %if(find(iplot(i)=[12 11]))
  leftlabel02 = [leftlabel '-' str2];
  text(tstartpanel1-0.05-
0.02,[yshift(i)],leftlabel02,'FontSize',8,...
      'HorizontalAlignment','right');
end

%end

if(stype==1);
   plottitle = sprintf('MD 2005 -- Record %g  Shot #%s  %s  ',...
     shotnum,source2,srcloc);
else
   plottitle = sprintf('MD 2005 -- Record %g  %s  %s  ',...
     shotnum,source2,srcloc);
end
title(plottitle,'FontSize',18,'FontWeight','Bold');
set(gcf,'PaperUnits','inches');
set(gcf,'PaperPosition',[0.5,0.5,7,10]);
set(gcf,'PaperOrientation','portrait');

if(iprint==1); print -dljetplus; delete(f1); end

return %-----------------------------------------------------------------
```

MD05label.m - to get sensor geometry, sensitivities, etc

This function is used to provide information about the experiment to the plot programs. It is called by plotNZ48FourCol.m and by plotNZ48.m. This function calls words.m to parse strings into individual words.

For each record number, the function returns the source type, size, and location as well as an array of sensor information including the locations, types, and sensitivities that can be used to convert sensor voltages to physical units. The function

tracks changes that were made to the sensor array during the test (when sensors failed and were replaced).

```
function [sensor,sensortype,rtype,sensorx,sensory,sensorz,...
          srcloc,sourcetype,stype,srcx,srcy,srcz,sourcesize,...
          engfact,dist,sensor2,source2] = MD05label
(x,shotnum,nchan)

% Fujitsu C:\aaaNZData\PlotATC05\MD05label.m
% Win2k D:\FY04Sydet\FY04LargeExplosionTest\MD04\MD04label.m
%  Returns channel ids for NZ seismograph used at MD 2004 test
%  calls words.m - breaks string into individual words

%  Don Albert dalbert@crrel.usace.army.mil
%  USA ERDC-CRREL, 72 Lyme Road, Hanover, NH 03755

nchan = 48;

% Sensor information ---------------------------------------
% Sensor coordinates
sensorx = (1:nchan)*0; sensory = (1:nchan)*0; sensorz =
(1:nchan)*0;
sensorx = [92,92,92,92, 62,62,62,62,     32,32,22,12, ...
           92,92,92,92, 62,62,62,62,     32,32,22,12, ...
       240,240,240,240, 180,180,180,180, 120,120,120,120, ...
       400,400,400,400, 370,370,370,370, 340,340,340,340];
sensory = [-15,-15,-15,-15, -15,-15,-15,-15, -15,-15,-15,-15, ...
               15,15,15,15,     15,15,15,15,     15,15,15,15, ...
        0,0,0,0, 0,0,0,0, 0,0,0,0, 0,0,0,0, 0,0,0,0, 0,0,0,0];

height15 = [3,8,10,11, 16,20,22,23, 28,32,36, 40,44,48 ];
sensorz(height15) = 1.5;

% Sensortype
for i = 1:nchan; sensortype(i)='P'; end
senv = [ 2 6 14 18 26 30 34 38 42 46]; sensortype(senv)='V';
senr = [ 1 5 13 17 25 29 33 37 41 45]; sensortype(senr)='R';
%sent = [ 12];                  sensortype(sent)='T';

sss = ['RP-92   VP-92   PP-92-1  PP-92-0 ' ... %1-4
       'RP-62   VP-62   PP-62-0  PP-62-1 ' ... %5-8
       'PP-32-0 PP-32-1 PP-22-1  PP-10-0 ' ... %9-12
       'RB-92   VB-92   PB-92-0  PB-92-1 ' ... %13-16
       'RB-62   VB-62   PB-62-0  PB-62-1 ' ... %17-20
       'PB-32-0 PB-32-1 PB-22-1  PB-10-0 ' ... %21-24
       'R-240   V-240   P-240-0  P-240-1 ' ... %25-28
       'R-180   V-180   P-180-0  P-180-1 ' ... %29-32
       'R-120   V-120   P-120-0  P-120-1 ' ... %33-36
       'R-400   V-400   P-400-0  P-400-1 ' ... %37-40
       'R-370   V-370   P-370-0  P-370-1 ' ... %41-44
       'R-340   V-340   P-340-0  P-340-1 '    ]; %45-48
sensor = words(sss);

%  Initial sensor array, changes during test listed below
```

```
%  Corrected location of 15974 on the ground, 15972 at 1.5 m
height
sss2 =[ ...
'MP-4.5Hz-geophone  MP-4.5Hz-geophone  PCB-106B50-6522   PCB-
106B50-6693  ' ...%1-4
'MP-4.5Hz-geophone  MP-4.5Hz-geophone  PCB-102A07-15973  PCB-
102A07-15971 ' ...%5-8
'PCB-102A09-15968   PCB-102A09-15969   PCB-102A06-15964  PCB-
102A09-15962 ' ...%9-12
'MP-4.5Hz-geophone  MP-4.5Hz-geophone  PCB-106B50-3259   PCB-
106B50-6695  ' ...%13-16
'MP-4.5Hz-geophone  MP-4.5Hz-geophone  PCB-102A07-15974  PCB-
102A09-12102 ' ...%17-20
'PCB-102A09-13180   PCB-102A09-15970   PCB-102A06-15966  PCB-
102A06-15965 ' ...%21-24
'MP-4.5Hz-geophone  MP-4.5Hz-geophone  B&K-4938-6   B&K-4938-5
' ...%25-28
'MP-4.5Hz-geophone  MP-4.5Hz-geophone  B&K-4938-4   B&K-4938-3
' ...%29-32
'MP-4.5Hz-geophone  MP-4.5Hz-geophone  B&K-4138-2   B&K-4938-1
' ...%33-36
'MP-4.5Hz-geophone  MP-4.5Hz-geophone  B&K-4165-6   B&K-4965-5
' ...%37-40
'MP-4.5Hz-geophone  MP-4.5Hz-geophone  B&K-4165-10  B&K-4165-9
' ...%41-44
'MP-4.5Hz-geophone  MP-4.5Hz-geophone  B&K-4165-8   B&K-4165-7
' ]; %45-48

sensor2 = words(sss2);

% rtype  1 = Microphone, 2 = PCB, 5= Vert, 6 = Horiz, 7 = Accel
rtype = [6 5 2 2  6 5 2 2  2 2 2 2   6 5 2 2  6 5 2 2  2 2 2 2
...
         6 5 1 1  6 5 1 1  6 5 1 1   6 5 1 1  6 5 1 1  6 5 1 1 ];

% engfact = units per mV
% mV = data_value*descal_fact/stack_count
% phys_units = data_value*descale_fact / (stack_count*engfact)

%Starting values:
engfact(1:nchan) = 1.0;
engfact([27 28 31 32 35 36 39 40 43 44 47 48]) = -1.0; %B&K po-
larity

% Calibrated values:  mV per m/s  and mV/Pa
% Calibrated values: -- B&K field cal and PCB cals at CRREL
(mV/Pa)
engfact = [
32.2*1000   -32.2*1000     0.0668      0.0636   ... %1-4
32.2*1000   -32.2*1000     11.56e-3    12.16e-3 ... %5-8
5.77e-3       5.60e-3      1.23e-3     1.21e-3  ... %9-12
32.2*1000   -32.2*1000     0.0778      0.0630   ... %13-16
32.2*1000   -32.2*1000     11.91e-3    5.14e-3  ... %17-20
5.42e-3       5.86e-3      1.22e-3     1.22e-3  ... %21-24
32.2*1000   -32.2*1000   -1.13/10     -1.24/10   ... %25-28
32.2*1000   -32.2*1000   -1.22/10     -1.11/10   ... %29-32
32.2*1000   -32.2*1000   -1.12/10     -1.05/10   ... %33-36
```

```
32.2*1000   -32.2*1000   -49.1/100    -47.5/100  ... %37-40
32.2*1000   -32.2*1000   -48.5/100    -49.6/100  ... %41-44
32.2*1000   -32.2*1000   -61.2/100    -57.4/100    ]; %45-48

% Changes to sensor array during tests
if(shotnum>=40); sensor2(21,:) = 'PCB-102A09-12101 ';
    engfact(21) = 4.88e-3; end
if(shotnum>=43); sensor2(21,:) = 'PCB-102A06-16784 ';
    engfact(21) = 1.16e-3; end
if(shotnum>=47); sensor2(12,:) = 'PCB-102A06-15503 ';
    engfact(12) = 1.28e-3; end
if(shotnum>=47); sensor2(11,:) = 'PCB-102A06-15961 ';
    engfact(11) = 1.26e-3; end

%  Source information -----------------------------------------
%  Default source info
srcloc = 'SP1';
srclocnum = 1; srcx = 0.0; srcy = 0.0; srcz = 1.5;
%  stype 1 = C4, 6 = 50 cal, 9 = 45 cal, 10 = noise
%  stype 3 = Claymore, 2 = DAM
%  stype 12 = Hammer, 13 = Cap, 14 = Calibration
sourcetype = 'C4'; stype = 1; sourcesize = 0;
source2 = 'Jungle';
%  MD05:  All shots were 1 brick of C4
sourcetype = 'C4'; stype = 1; sourcesize = 1;

%  C4 shots
if( shotnum ==38 | shotnum ==40 | shotnum ==75 | ...
    shotnum ==77 | shotnum ==79)
   srcloc = 'B+2+1.5'; srcx = 2.0; srcy = 15.0; srcz = 1.5;
end
if( shotnum ==39 | shotnum ==42 | shotnum ==76 | ...
    shotnum ==78 | shotnum ==80)
   srcloc = 'P+2+1.5'; srcx = 2.0; srcy =-15.0; srcz = 1.5;
end
if( shotnum ==37 | shotnum ==43| shotnum ==45 | ...
    shotnum ==81 | shotnum ==83 | shotnum ==85)
   srcloc = 'B-5+3'; srcx = -5.0; srcy = 15.0; srcz = 3.0;
end
if( shotnum ==44 | shotnum ==46 | shotnum ==82 | ...
    shotnum ==84 | shotnum ==86)
   srcloc = 'P-5+3'; srcx = -5.0; srcy =-15.0; srcz = 3.0;
end
if( shotnum ==69 | shotnum ==71 | ...
    shotnum ==87 |shotnum ==89 | shotnum ==91)
   srcloc = 'B-5+1'; srcx = -5.0; srcy = 15.0; srcz = 1.0;
end
if( shotnum ==70 | shotnum ==72 | ...
    shotnum ==88 |shotnum ==90 | shotnum ==92)
   srcloc = 'P-5+1'; srcx = -5.0; srcy =-15.0; srcz = 1.0;
end
if( shotnum ==73 )
   srcloc = 'B-5+1.5'; srcx = -5.0; srcy = 15.0; srcz = 1.5;
end
if( shotnum ==74 )
   srcloc = 'P-5+1.5'; srcx = -5.0; srcy =-15.0; srcz = 1.5;
end
```

```
if((shotnum >=37 & shotnum <= 40)); source2=num2str(shotnum-36);
end
if((shotnum >=42 & shotnum <= 46)); source2=num2str(shotnum-37);
end
if((shotnum >=69 & shotnum <= 92)); source2=num2str(shotnum-59);
end
%  Other source info

if(shotnum <=8 | (shotnum >=12 & shotnum <= 35) | ...
   (shotnum >= 93 & shotnum <= 104) | ...
   (shotnum >=112 & shotnum <= 147) )
   sourcetype = 'Calibration';stype = 14; srcz = 0.0;
source2='Cal';
end
if(shotnum ==106 | shotnum ==107 | shotnum ==108)
   sourcetype = 'Blasting Cap';stype = 15; source2='Cap';
   srcloc = 'P+2+2'; srcx = 2.0; srcy =-15.0; srcz = 2.0;
end
if(shotnum ==109 | shotnum ==110 | shotnum ==111)
   sourcetype = 'Blasting Cap';stype = 15; source2='Cap';
   srcloc = 'BP+2+2'; srcx = 2.0; srcy = 15.0; srcz = 2.0;
end

if( shotnum ==36  | shotnum ==41 | shotnum ==105 | shotnum ==47 |
...
    shotnum ==68 | shotnum ==999 | shotnum ==999 | shotnum
==999);
    sourcetype = 'Noise';stype = 10; srcz = 0.0; source2='Noise';
    srcloc = ' ';
end
if(shotnum >=8 & shotnum <=11)
   sourcetype = 'Vehicle';stype = 15; source2='Vehicle';
   srcloc = 'Road'; srcx = 240.0; srcy = 100.0; srcz = 3.0;
end

%  Blank pistol shots along the sensor array
if( (shotnum >=48 & shotnum <=67))
   sourcetype = '45 cal blank'; stype = 9; source2='Pistol';
   sourcesize = 0; srcz = 1.0;
   if( (shotnum >=48 & shotnum <=52))
       srcx = 280.0; srcloc = '280 m'; srclocnum = 7;
   end
   if( (shotnum >=53 & shotnum <=57))
       srcx = 310.0; srcloc = '310 m'; srclocnum = 8;
   end
   if( (shotnum >=58 & shotnum <=62))
       srcx = 430.0; srcloc = '430 m'; srclocnum = 9;
   end
   if( (shotnum >=63 & shotnum <=67))
       srcx = 280.0; srcloc = '280 m'; srclocnum = 7;
   end
end

%  Source to sensor distances  ----------------------------------
srcx2 = srcx*srcx; srcy2 = srcy*srcy; srcz2 = srcz*srcz;
for i=1:nchan
   dist(i) = ((sensorx(i)-srcx).^2 +  ...
```

```
      (sensory(i)-srcy).^2 + ...
      (sensorz(i)-srcz).^2  ) .^0.5;
end

return  %-------------------------------------------------------
```

Appendix B. StrataVisor NZ Recorder Specifications

GEOMETRICS

StrataVisor™ NZ Exploration Seismograph and Field PC

- **Professional, ruggedized 24 bit seismic recorder suitable for reflection, refraction, downhole, VSP or small marine surveys. Intelligent self-trigger enables vibration and earthquake monitoring.**
- **Houses from 3 to 64 channels. Expands seamlessly up to 1000 channels by connecting Geode in-field distributed modules.**
- **Engineered for rugged field use: reliable in harsh environments, survives shock, humidity and dust. Passes MIL 810E vibration spec.**
- **20 kHz bandwidth (0.02 μs to 16 ms sampling) for ultra-high resolution engineering surveys or low frequencies for earthquake monitoring.**
- **Brilliant full-sun-visible color screen and built-in plotter - available also as rugged field computer without seismic channels.**
- **Built-in geophone and line testing, full waveform noise monitor. Optional automated internal in-field instrument testing or detachable lab quality external test oscillator.**
- **High-speed hardware correlator means no delays using Vibroseis or pseudo-random Mini-Sosie sources.**
- **Powerful reflection, refraction and cross hole tomography software:**
  - Model local geology and display travel-time curves before surveying
  - Pick breaks on site and view travel-time curves for optimum shot positioning
  - Display in-field preliminary cross section and ray coverage plots to see what you have missed
  - Undertake a comprehensive analysis back at the office and easily compare results with alternate interpretation methods

The StrataVisor™ NZ is a high-performance exploration seismic system in a compact, weatherproof chassis. The NZ can operate as a field PC, as a stand-alone seismic recorder with 3 to 64 internal channels - or expands easily to larger channel systems by connecting Geode remote distributed modules. This flexibility lets you collect data for all applications in all environments – you can even rent extra channels when needed.

Examine your data at all phases of acquisition to ensure data quality. Customizable windows show real-time noise monitor, amplitude spectra and seismic traces so you see problems instantly. A log file keeps track of all parameter changes and customizable alarms alert you to critical issues. You can even do preliminary processing in the field with industry-leading reflection, refraction and tomography software included with every system.

The StrataVisor NZ console includes a brilliant daylight-visible color screen, waterproof keypad and built-in printer. Low-power circuitry and a standby mode extend battery life and reduce weight. A tape drive controller, Vibroseis sweep generator and intelligent integration of GPS and other survey data can be included.

The StrataVisor NZ is backed by a 1 year parts and labor warranty. All this from a company with factory trained service centers world wide and over 30 years of superior support to geoscience professionals.

StrataVisor™ NZ Exploration Seismic Recorder

Specifications:

Configurations:

- Lightweight field-rugged PC with no seismic channels for use as field computer or rugged in-field controller for Geode distributed modules
- Integrated seismic recorder - add 3, 6, 8, 12 or 16 to 64 built-in channels (in 8 channel increments)
- Connect multiple NZ's and operate from a single keypad

Runs Windows™ operating system and includes all software for controlling internal channels and multiple lines of Geode modules. Total number of channels limited only by practical survey requirements.

A/D Conversion: 24 bit result using Crystal Semiconductor sigma-delta converters and Geometrics proprietary over-sampling.

Dynamic Range: 144 dB (system), 110 dB (instantaneous, measured) at 2 ms, 24 dB.

Distortion: 0.0005% @ 2 ms, 1.75 to 208 Hz.

Bandwidth: 1.75 Hz to 20 kHz. Low corner frequency option available.

Common Mode Rejection: > 100dB at <= 100 Hz, 36 dB.

Cross Talk: -125 dB at 23.5 Hz, 24 dB, 2 ms.

Noise Floor: 0.20 µV, RFI at 2 ms, 36 dB, 1.75 to 208 Hz.

Stacking Trigger Accuracy: 1/32 of sample interval.

Maximum Input Signal: 2.8V PP, 0 dB, 177 mV PP, 24 dB.

Input Impedance: 20 kOhm, 0.02 µf.

Preamplifier Gains: Standard factory configuration is 24 and 36 db, selectable in software. Optionally, can be jumpered for software selectable 12 and 24 dB or can be jumpered in four channel blocks as a single fixed gain of 0 dB for high-voltage devices.

Anti-alias Filters: -3 dB at 83% of Nyquist down 90 dB.

Acquisition and Display Filters:
Low Cut: OUT, 10, 15, 25, 35, 50, 70, 100, 140, 200, 280, 400 Hz, 24 or 48 dB/octave, Butterworth.
Notch: 50, 60, 150, 180 Hz and OUT, with the 50 dB rejection bandwidth 2% of center frequency.
High Cut: OUT, 250, 500 or 1000 Hz, 24 or 48 dB/ octave.
Customer filter frequencies available as an option.

Sample Interval: 0.02, 0.03125, 0.0625, 0.125, 0.25, 0.5, 1.0, 2.0, 4.0, 8.0, 16.0 ms.

Correlation: Built-in high-speed hardware correlator for Vibroseis. Optional pilot conditioning for acquisition of pseudo-random (MiniSosie) sources.

Record Length: 16,384 samples standard, 65,536 samples optional.

Pre-trigger Data: Up to full record length.

Intelligent Self-Trigger: Available for earthquake and vibration monitoring.

Continuous Recording: Available for vibration monitoring.

Delay: 0 to 100 sec in 1 sample steps.

Auxiliary Channels: All channels can be programmed as either AUX or DATA.

CDP Roll Along: Software selectable channels can be rolled through total channels.

Line Testing: Full waveform noise monitor displays real-time output from geophones. Tests geophones and locates shorted or broken cables.

Optional Built-In Test Functions

Digital:
- CPU diagnostics
- Internal network test
- Digital functions
- Battery Warning

Instrument:
- Noise
- DC Offset
- Gain Accuracy
- Gain and Phase Similarity
- Distortion
- Crossfeed
- Bandwidth
- Timing Accuracy

Line:
- Geophone similarity
- Noise
- Disconnected phones

Instrument Tests: Available either internally or as detachable external system. Test scripts are customizable to meet your clients needs.

Data Formats: SEG-2, SEG-D and SEG-Y.

System Software: Runs under Windows™ operating system. Uses Geometrics MGOS software to control acquisition on internal channels and up to 4 lines of external channels housed in Geode distributed modules. System includes the following 2nd party applications software:

- SIPQC delay time refraction software from Rimrock Geophysics
- SeisImager refraction modeling and analysis software from OYO
- WinSeis-Turbo reflection software from the Kansas Geological Survey

Refraction software packages installed on instrument are configured for in-field analysis and may require attaching a keyboard and mouse. Full desktop versions of these packages are available either from Geometrics.

Data Storage: Stores data on internal hard drive or controls multiple SCSI tape devices. Records in SEG2, SEGY or SEGD.

Plotters: Built-in 4" thermal plotter. Drives a variety of NT compatible plotters including Printrex 4, 8 and 12 inch continuous thermal plotters.

Triggering: Positive, negative or contact closure, software adjustable threshold.

Power: 30W plus 0.65W/channel during acquisition. Standby mode reduces channel power consumption by 70%. Requires external 12V supply.

Environmental: Boots from +5°C to 40°C. Operates from –5°C to 40°C. Extended temperature version available to +60°C. Operates in a light rain, watertight with cover closed. Passes MIL810E/F vibration test.

Physical:
Field PC with no seismic channels: 10.5"L x 18"W x 13"D (27cm L x 46 cm w x 46 cm D), weighs 27 lb (12.3 kg)
Seismic recorder with 3-64 internal channels: 10.5"L x 18"W x 21 "D (26.7cm L x 34 cm W x 33 cm D), weighs 38 lb (18 kg)

Warranty: One year parts and labor. Extended warranty available.

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14. ABSTRACT

Complaints about Army training noise, especially artillery noise, are increasing and are impacting soldier training opportunities. One suggested mitigation method is to use a gravel pad near the noise source to reduce blast noise. Measurements were conducted to assess this method by detonating C4 charges located over a 15- × 15- × 1.5-m-thick gravel pad or over undisturbed ground and recording the acoustic and seismic waveforms at various distances from the source. The measurements recorded by ERDC-CRREL personnel at propagation distances from 10 to 400 m are documented in this report. Additional reports documenting the longer distance measurements and analyzing the measurements are planned.

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